
ECONOMIC STRUCTURE AND GROWTH

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Abstract

The purpose of this study is to analyse the impact of the economic structure on economic growth, a question that brings together economic growth and development economics. In particular, we want to assess if a high specialization in some sectors, as opposed to a more diversified economy, influences the rate of growth of the economy. Our results indicate that, although not uniform between countries from different regions and income levels, economic structure plays a role in the explanation of economic growth.

JEL codes: O10, O40, 050

Keywords: Economic Growth, Economic Structure, Specialization, Diversification

Resumo

O objectivo deste estudo passa por analisar o impacto da estrutura da economia no crescimento económico, uma questão transversal ao crescimento e ao desenvolvimento económico. Em particular, queremos avaliar se uma maior especialização em determinados sectores, em comparação com uma economia mais diversificada, influencia a taxa de crescimento da economia. Os nossos resultados indicam que, embora não uniforme entre países de regiões e níveis de rendimento diferentes, a estrutura da economia é importante para explicar o crescimento económico.

Classificação JEL: O10, 040, 050

Palavras-chave: Crescimento Económico, Estrutura da Economia, Especialização, Diversificação

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1. Introduction

Economies from all over the world are all different. Some countries have a specialization in the production of a specific good, while others produce a diverse range of products. Some countries face continuous growth while others are stagnated or show an unstable pattern. It is conceivable that these two dimensions – economic structure and economic growth – are related. Therefore, the purpose of this study is to analyse whether a high specialization in some sectors, as opposed to a more diversified economy, influences the rate of growth of the economy.

The causes of economic growth had intrigued philosophers and political thinkers since the beginning of times. It can be argued that this question is on the origin of economics as a science. Several possible explanations have been proposed, especially after Solow (1956) and his growth theory based on the accumulation of physical inputs, such as labour and capital (including land), and on technological progress. Once the “technological progress” cannot be observed, this factor can capture the effect of several elements, where we can include the structure of the economy. This theoretical framework, associated with the fact that nowadays several countries (mainly developing countries) are highly dependent on the performance of natural resource exploration (natural gas, oil and hard minerals), motivate this study that will try to answer the general question “Why is diversification so important?”

As the above question is, however, still quite general, we defined three more specific questions which will allow us to reach a conclusion: What’s the impact of the structure of the economy on economic growth? Does this impact depend on the dominant sector? Does the economic structure effect depend on the sectoral branches within the economy?

In order to do that, we will develop a model, formalizing a general relationship between the two referred concepts (economic structure and economic growth), using a growth-accounting framework. We also analysed diversities across countries from diverse regions and having different income levels. A deeper analysis of some particular sectors was developed in order to test if the presented results are sensitive to the sector considered. Lastly, we analysed if the economic complexity impacts on economic growth.

Our results indicate that, although not uniform between countries from different regions and income levels, economic structure plays a role in the explanation of economic growth.

Several studies tried to explain the relationship between these two dimensions. The present paper, however, pursues a slightly different point of view. While other studies confront the complexity of the economy or the sectoral composition of national production with economic growth, this research aims to understand the possible impact of the structure of the economy on economic growth. This study could, also, be helpful to define growth promoting guidelines, especially in developing countries.

The remainder of the study is organized as follows. In the following section, we review the literature that analyses the relationship between economic structure and economic growth. In the third section, we explain our approach to the measurement of the economic structure and the data used. In the fourth section, we describe the empirical model estimated, reveal the general results obtained and explore differences between regions, income levels and export clubs. Section 5 goes further and includes economic complexity as a possible explanation for growth. The last section concludes.

2. Literature review

Although our objective is to study the impact of economic structure on economic growth, the lack of studies addressing our question leads us to refer similar works that do not use the exact approach we want to pursue. We also choose to refer studies with “level effects” although our interest lies in the “growth effects”. Both empirical and theoretical literature was considered. The available empirical evidence on the relationship between economic structure and economic growth is not conclusive. Although the majority of studies within this topic are employed on a regional level, analysis differs on time or area under study, the measures of diversification/specialization used, the industrial taxonomy considered and even on the methods applied.

2.1 The Classic View

The causes of economic growth had intrigued philosophers and political thinkers since the beginning of times. It can be argued that this question is on the origin of economics as a science. Indeed, since Adam Smith (1776) and his theory of specialization, several authors explored this issue. However, we needed to wait almost two hundred years before the Solow growth model. This model changed the paradigm and provided a decisive impulse to the study of economic growth. Since then and up to now, the study of economic growth has seen a continuous and solid evolution.

Solow (1956) proposes a growth theory based on the accumulation of physical inputs, such as labour and capital (including land), and on technological progress. Once the “technological progress” cannot be observed, this factor can capture the effect of several elements – the well-known “Solow residual”. Many economists have tried to identify all the possible sources of growth, ever since.

2.2 Growth and Development

At a certain point, these studies began to consider the structure of the economy as a possible explanatory variable of economic growth. Lewis (1954), Rostow (1959), Chenery (1960, 1982), among others, studied structural transformation as the process of reallocation of production structure that accompanies the process of economic growth and Kuznets (1971) exploited the impact of changes in sectoral composition on economic growth. But

the idea of the structure of the economy impacting economic growth goes back to Young (1928). This author pointed to the relationships between the various industries¹ in the economy as having impact on the growth pattern of the economy.

The majority of this studies converges to the idea of a two-way causality between economic growth and structural change. This is, during the development process, while economies move from agriculture and extractive industries to more sophisticated forms of manufacturing and services, the mechanics of growth and structural change interchange effects in a dynamic way.

Related to this older line of research, but focused on a much broader approach, Imbs and Wacziarg (2003) and Klinger and Lederman (2004) studied how the economic structure evolves with development. The first studied the evolution of sectoral concentration in relation to the level of per capita income for a wide range of industrial and developing countries. Using nonparametric methods, they found that the relationship between sectoral diversification and income follows a U-shaped pattern: countries first tend to diversify, but lately on the development process occurs the inverse and countries start specializing again. One possible explanation for this evolution can be found in the work of Klinger and Lederman (2004). They analyzed the evolution of export discoveries – new export products introduced – on the level of development by applying panel estimation models to data from 99 countries for various time periods. Although the discovery activity is just one of two channels for diversification to occur – being the other a more evenly production across all the existing sectors - the result suggests discovery to be an important element to understand the evolution of the economic structure with development. Discovery activity appears to follow an inverted U-curve in income: the number of new export products increases with income when countries are in development, on a later stage the discovery activity declines and countries start specializing again.

In the late 90's a new approach appeared. This view tries to achieve simultaneously structural transformation and a balanced growth path, by constructing models where the continuous process of production and employment reallocation between sectors go hand in hand with the stable behaviour that characterizes the aggregate variables in a balanced growth path. Broadly speaking, this approach aims to gather the abovementioned Kuznets

¹ In this study, we are going to use the terms “industry” and “sector” without distinction.

facts with the well-known Kaldor facts² in a single model. This literature divided into two branches, according to the considered driving force behind the structural transformation.

Some authors, such as Echevarria (1997), Kongsamut *et al.* (2001) and Foelmi and Zweimüller (2008) believe that structural change occurs due to sectoral differences in income elasticities of demand. This “demand-side” explanation states that the marginal rate of substitution between different goods changes as an economy grows, decreasing the relative weight of necessities and increasing the share of luxury goods on total expenditures, a theory that it’s aligned with Engel’s law. Echevarria (1997) represents – to the best of our knowledge – the first attempt to reconcile the structural transformation within the usual growth models framework. This paper presents a dynamic general equilibrium model with different income elasticities for the three sectors considered – primaries, manufacturing and services. Kongsamut *et al.* (2001) developed a standard growth model; but, in contrast with Echevarria (1997), only required the real interest rate to remain constant over time – a generalized balanced growth path. Foelmi and Zweimüller (2008) proposed a different technique. In their model, new goods are continuously introduced into the economy. With a hierarchic utility function, the production of new goods increases while old industries disappear. Sectoral differences in income elasticities arise, leading to the structural change that affects economic growth.

Other authors, such as Ngai and Pissarides (2007) and Acemoglu and Guerrieri (2008) rely on the relative price change effect as the cause of structural change. This mechanism reflects differences in Total Factor Productivity (TFP) growth rates across sectors and is inspired by the seminal contribution of Baumol (1967), which explains the structural change as a result of a “supply-side” phenomenon. Baumol argues that the economy can be divided into two sectors – a “progressive” and a “non-progressive” sector. While the “progressive” sector exhibits technological progress, the “non-progressive” sector remains technologically unchanged over time. This “technological” explanation was the key mechanism besides the model of Ngai and Pissarides (2007), which considers TFP differences across sectors to be exogenous. Their results confirm Baumol’s claim about structural change: over time the labour force is channelled from the high to the low TFP activities. The same model, however, predicts a different pattern if we consider a finer sector decomposition. In this case, within the subsectors, there is an inverse flow with

² Kaldor (1961) points out the stable behaviour of the growth rate of output, the capital-output ratio, the share of capital income in GDP and the real interest rate, which are all approximately stationary over time. These “stylized facts” have been used ever since.

labour moving from low to high TFP goods. Acemoglu and Guerrieri (2008) pursued another explanation, although closer to that of Ngai and Pissarides (2007). Their two-sector general equilibrium model states that nonbalanced growth is based on differences in factor proportions (capital intensities) between sectors and capital deepening. As a result, there is an increase in the relative output of the more capital-intensive sector while there is a shift of capital and labour away from this sector.

Both mechanisms – income effects and relative price changes – are believed to account for structural transformation. Although the majority of studies within this framework usually apply one of them separately, some authors tried to explain the joint possibility of structural transformation and balanced growth path considering both effects at once. Bonatti and Felice (2007) extended the analysis of Echevarria (1997) and Kongsmaut *et al.* (2001) by allowing for endogenous growth and for relaxing the condition of equal TFP growth rate across sectors. Their two-sector endogenous growth model show under what circumstances on preferences Baumol’s claim occurs. Lately, Boppart (2014) presents structural change as a result both from income effects and substitution effects. Applying the model to the U.S. economy, concluded that both channels appear to have roughly the same importance explaining the observed structural change.

2.3 The emergence of “product space”

Lately emerged the concept of “product space” created by Hausmann *et al.* (2007). This concept was built on the idea of Hirschman (1958), who studied backwards and forward linkages across economic sectors and suggested that industrialization creates externalities that can promote economic growth. Within this framework, economic sectors are distributed accordingly with their linkages and the available capabilities in the country. The impact of economic structure on economic growth varies accordingly with the sectors in which the country is specialized, being some products associated with higher productivity levels than others. They conclude that “rich (poor) countries export products that tend to be exported by other rich (poor) countries” (p. 10) and, therefore, measures of economic complexity can predict future economic growth.

This new concept revolutionized the study of the economic structure and promoted further research on the impact of economic complexity on economic growth. Hidalgo and Hausmann (2009), Boschma *et al.* (2012), Felipe *et al.* (2012), and Ferrarini and

Scaramozzino (2016), using different approaches, all conclude that economic complexity affects economic growth.

The first concludes that countries tend to converge to the income associated with the products they produce. Thus, to promote growth, policymakers should generate conditions to increase production complexity. Since some products have associated a higher spillover effect than others, ventures to produce more complex goods – more linked within the product space – allow accumulating new capabilities, essential to produce even more complex products and, thus, expand the country's set of abilities.

Both Boschma *et al.* (2012) and Felipe *et al.* (2012) applied the methodology proposed by Hidalgo and Hausmann. Felipe *et al.* (2012), studying 124 countries and 5107 products, found that the complexity of the exports changes with income. The exports of more (less) complex products increase (decrease) with the level of development of the country. They confirmed the theories of Hidalgo and Hausmann (2009), arguing to the need of “policies that foster the accumulation of capabilities and promote the development of new more complex products, i.e., diversify” (p. 52). Boschma *et al.* (2012), studying Spanish regions economic performance between 1988 and 2008, also conclude that territories should diversify, but “into industries that are related to the existing set of industries” (p. 2), to allow knowledge spillovers to occur.

Ferrarini and Scaramozzino (2016) follow the same idea studying both growth and level effects of production complexity on economic growth. Their endogenous growth model considers that production complexity plays a dual role: can promote human capital accumulation –following Lucas' human capital theory (Lucas, 1988) –, and increase the risk of production failure – consistent with Kremer's O-ring theory (Kremer, 1993). They conclude that “increased complexity has an ambiguous effect on the level of output, but positively impacts economic growth by enhancing human capital formation” (p. 17).

2.4 Structure and Growth at a Regional Level

Another trend in the literature, based on the pioneering work of Chinitz (1961), tries to explain the relationship between economic structure and growth at a regional level. We consider this literature as relevant to our study and choose to refer to it even though the different geographic scale makes difficult for direct comparisons.

This literature usually studies how economic structure relates to innovation and, therefore, with economic growth. There are two competing theories to explain this relationship. Jacobs (1969) stated that innovation occurs from the spillover effect through different sectors or *inter*-sectoral spillovers. A more diversified economy promotes the interaction between industries, which allows a “cross-fertilization” of ideas and fosters the appearance of new products and technologies. On the opposite side, Marshall (1890) considers that *intra*-sectoral spillovers, or spillovers occurring within a sector, are the driving force behind regional economic growth. It is assumed that specialization on a given sector leads to productivity gains through process innovation.

Empirical studies tried to understand which of the effects, spillovers occurring from diversification or specialization, is stronger. While Wagner and Deller (1998), studying the 50 US states for the period 1969-1992, found a positive impact of diversity on growth, Attaran (1986), comparing industrial diversity with economic performance – measured either by unemployment and per capita income –, in US areas (50 states and the District of Columbia) for the ten-year period 1972-1981, discovered an unexpected negative effect of diversity on per capita income growth at the region level. The results also reveal a negative but very weakly correlation between diversity and unemployment growth. A similar result was obtained by Glaeser *et al.* (1992) considering data from 170 American cities for the period 1956-1987. They found specialization to be negatively correlated with employment growth, in opposition to diversification which appears to have a positive effect, consistent with the theories of Jacobs. Besides this, Izraeli and Murphy (2003), applying panel data techniques – which allow controlling for unobserved individual heterogeneity - with a sample of 17 US states spanning a 38-year period (1960-1997) do not find any significant impact of diversity on per capita income growth.

Two other studies were conducted for the case of the Netherlands. Van Stel and Nieuwenhuijsen (2004), studying the impact of knowledge spillovers on economic growth, found a positive effect of diversity on value-added growth. Frenken *et al.* (2007), analyzing the effect of variety on regional economic growth, found that related variety – within sectors – enhances economic growth, while unrelated variety – between sectors (diversification) – has a negative effect on unemployment growth. Both analysis used data from Dutch regions at the NUTS 3 level.

It should also be stressed another theory that relates economic structure with stability and, therefore, with economic growth. The literature pioneered by McLaughlin (1930), Hoover (1948) and Nourse (1968) argue that diversity promotes economic stability.

A more diversified economy is believed to become less responsive to business fluctuations than a more specialized one. Diversification allows the stability of employment and income through compensating seasonal and cyclical fluctuations across a wide range of industries. On the long-run, as stated by Hoover (1948), “diversification affords some insurance against the total collapse of the economic life” (p. 288). The employment of complimentary labour groups – contrary to just one or few groups of workers employed in the case of more specialized economies – makes it easier to replace declining industries and, therefore, allows to protect against secular and structural changes. Pasinetti (1993) goes further and analyses this impact through employment, considering that without diversification an economy will suffer from structural unemployment and, consequently, low economic growth.

This theory also argues that specialization cannot protect the economy from external shocks in demand (Attaran, 1986; Izraeli and Murphy, 2001). On contrary, the process of diversification increases the degree of risk spreading that an economy can achieve (Acemoglu and Zilibotti, 1997). With diversification, the effect of sector-specific shocks is mitigated through a broader portfolio of economic sectors, which fosters investment and the development of financial markets. This will ultimately promote economic growth. Frenken *et al.* (2007), using the well-known “portfolio theory” of Montgomery (1994), also argues that policymakers should pursue the strategy of enhancing variety across sectors with the purpose of reducing this risk.

3. The Economic Structure

The main aim of this study is to analyze the impact of the economic structure on the economic growth. Therefore, in this section, we should explain, firstly, what we understand by “economic structure” and, secondly, how we intend to measure it.

3.1 Definition

The concept of “economic structure” that we introduced in the first section still looks for a definitive meaning in the literature. Sometimes referred to as the “production structure”, it is still a quite vague idea that is modelled in various ways, accordingly with the context, the authors’ intents and the data available. Nevertheless, the definition that we are going to adopt in this study shows general acceptance.

When we refer to the “economic structure”, we have in mind the different sectors within an economy – in this case at a country level –, their relative sizes and the linkages between them. In this sense, according to the distribution of the national production across the different industries, a country can be considered specialized or diversified. This idea, however, is not so simple. As Rodgers (1957) pointed out, this definition is based on the concept of a “balanced industrial structure”, which, as he argues, “is extremely seductive because of the difficulty of defining ‘balance’ in any realistic sense” (p. 16). In fact, we cannot find a precise definition of “specialization” or “diversification” in the literature. An economy is said to be diversified “if there is variety of employment in different industries” (McLaughlin, 1930, p. 132), “if occurs the presence in an area of a great number of different types of industries” (Rodgers, 1957, p. 16) or “if the economic activity of a region is distributed among a number of categories” (Parr, 1965, p. 22). By the other hand, an economy is considered to be specialized “if only a few industries account for a large share of its total production” (Aiginger and Davies, 2004, p. 235).

It is not the objective of this study to build a clear and precise definition of “specialization” and “diversification”. In this study, we assume an economy is diversified if there is no industry or group of industries that account for a large share of economic activity. On the contrary, a specialized economy is the one where one or a few sectors represent a large amount of national production. We have no necessity to define clear thresholds since we just need to assure the possibility of cross-country and time-series

comparisons. Despite some debate,³ we assume specialization as the exact opposite of diversification, in line with Hoover (1948), Leser (1949), and Wagner and Deller (1998).

3.2 Measurement

Since we have defined what “economic structure” means for the purpose of this study, we shall now briefly discuss the main problems related with its measurement: sector’s size dimensions, the indicator of specialization/diversification and the level of aggregation.

3.2.1 Sector’s size dimensions

The first issue concerning the measurement of the economic structure is to choose the adequate dimension to assess the weight of the different sectors of the economy. It is possible to capture the sector’s weight by looking at production – both inputs and outputs – or international trade data. The latter has the advantage to be recorded at highly disaggregated levels (Klinger and Lederman, 2004) and is collected in a standardized classification that makes comparisons between countries possible. However, trade data has two major drawbacks. It does not include products that are produced and consumed in the domestic market and is limited to goods, excluding data on services (Bustos *et al.*, 2012). Thus, production data will be preferred against data on trade in this study.

Within production data, we can use data on inputs or outputs. As Herrendorf *et al.* (2013) pointed out, the most common measures of production at the sectoral level are employment (number of workers or hours worked), value added and final consumption shares. Each one of them is distinct and we should be aware of their limitations as singular measures. In the case of employment, we should note that hours worked may not be proportional to the number of workers across sectors. The number of workers could also not capture the true value of “human capital” per worker. The labour-capital intensity differs across sectors, with higher capital intensities implying higher depreciation and a lower share of wages in value added.⁴ According to Herrendorf *et al.* (2013), value added and consumption expenditure shares need also to account for changes in quantities and prices. Inventories stock also justifies differences between value added and the value of

³ We should refer the studies of Malizia and Ke (1993) and Hong and Xiao (2016) that considered the possibility of coexistence between specialization and diversification in the form of “diversified or multiple specializations”.

⁴ See United Nations (2008, p.21) and Herrendorf *et al.* (2013, p. 6-7), for further discussion.

sales (turnover). Certain is that no dimension should be considered alone. Thus, in this study, we are going to use data both on employment and on value added.

3.2.2 The indicator of specialization/diversification

The distribution of the sector's weight can be synthesized considering different indicators that can be found in the literature.⁵ The choice of the indicator to be used, however, requires careful analysis because different indicators have different properties. There are several classes of indicators to measure the economic structure. Since we understand diversification and specialization as exact opposites, both kinds of indicators can be considered.

The simplest quantitative approaches solely measure the fraction of economic size – value added in the case of McLaughlin (1930) or employment in Reinwald (1949) – in a predetermined number of industries defined in an arbitrary sense. These “concentration ratios” fail to look at the complete distribution of sectoral shares within a national economy since they only use the largest industries and, thus, will not be used in this study.

Later studies developed measures that implicitly assume the concept of a “normal proportion of industry” – as noted by Conroy (1975) – where the benchmark could be another economy (measures of relative specialization) or a theoretically balanced structure with an equi-proportional distribution of employment or value added among all industries (measures of absolute specialization). These measures have received substantial criticism, either because of the implicit assumption that every area should follow the same industrial structure – not considering different factor endowments and different spatial relationships to markets that every area possesses (Conroy, 1975) – or because of the questionable economic reasonability of a meaningfully balanced economy – forgetting “the inherent intersectoral differences in the patterns of demand, labor productivity, and the organizational and institutional structures among various economic activities” (Wasylenko and Erickson, 1978, p. 108). This type of measures, however, has found considerable adherence in the literature. As argued by Kort (1981), their use does not claim an equi-proportional distribution across industries; but, by definition, if an economy is equally distributed across all industries then further diversification is impossible. Within this class

⁵ The majority of the indicators of specialization or diversification cited in this section was applied at a regional level. Despite the different geographic unit all the considerations remain valid at a national level. See Appendix A for a summary revision of the literature on the measurement of economic structure.

of indicators are the “specialization index”, the “entropy index” and the “Herfindahl-Hirschman index”, which we will apply in this study.

The “specialization index” is one of the most widely used indexes of relative specialization.⁶ Although one can build this index adopting different approaches, it always performs a comparison between two economies, using one of them – which can be a country or a larger area – as a reference for a balanced structure. Therefore, the specialization index (SI) can be defined as the summation of absolute differences of each sector’s relative national weight against the economy of reference, in this case, the aggregate of all countries. Let X_{ij} = employment/value added of industry i in country j , $i = 1, \dots, n, j = 1, \dots, k, \sum_i X_{ij} = X_j$ = total employment/value added of all industries in country j , $\sum_j X_{ij} = X_i$ = total employment/value added of industry i in all countries and $\sum_j X_j = \sum_i X_i = X$ = total employment/value added of all industries in all countries. Then, SI may be computed as:

$$(3.1) \quad SI = \sum_i \left| \frac{X_{ij}}{X_j} - \left(\frac{X_i - X_{ij}}{X - X_j} \right) \right|$$

Since larger countries contribute more to the benchmark than smaller ones, as noted by Palon (2010), the specialization tends to be underestimated for larger countries and overestimated for the small ones. In order to overcome this problem and obtain unbiased results, we correct the index by using as the reference area all the countries without the country under study.⁷ This index ranges from zero, if country j presents the same economic structure as the reference area, to two, if there is not a common sector between country j and the reference area.

This indicator does not provide any clue about the absolute level of specialization of a given country. Since it only compares the specialization of a country with the benchmark it can vary even if the economic structure of the country remains exactly the same across time, only needs the reference area to change. Absolute measures of specialization, which takes an equi-proportional economic structure as a reference, do not share this problem. These measures, such as the entropy index or the “Herfindahl-Hirschman index”, are then,

⁶ See Palon (2010) for a detailed discussion on absolute and relative measures of specialization.

⁷ In this study, we use as the reference area all the countries listed in the corresponding panel (see data coverage in Appendix B).

from this point of view, the most appropriate to study the impact of economic structure on growth.

Following Aiginger and Davies (2004), the entropy index has two desirable properties. First, it can be decomposed at each sectoral level of aggregation, allowing an exact relationship between changes in the individual industries and the aggregate change of the economy as a whole. Second, contrary to the concentration ratios, it uses the complete distribution of employment or value added across industries.

The entropy index⁸ uses as the norm of reference a uniform distribution of economic activity across all industries. Our approach follows Aiginger and Davies (2004). Let X_{ij} = employment/value-added of industry i in country j , $i = 1, \dots, n$, $j = 1, \dots, k$ and $\sum_i X_{ij} = X_j$ = total employment/value added of all industries in country j . Then, for a given country, the entropy index (EI) is calculated as the sum of the products of the shares and log shares⁹ of each industry in the overall economy, that is:

$$(3.2) \quad EI = - \sum_i \left[\left(\frac{X_{ij}}{X_j} \right) \ln \left(\frac{X_{ij}}{X_j} \right) \right]$$

It is an index of diversification. Its value ranges from a minimum of 0 when the whole employment/value added is concentrated in a single industry and a maximum of $\ln(n)$, when the economic activity is equally distributed across all industries. Therefore, the entropy index increases as employment or value added become more evenly distributed across sectors.

Since each indicator has its own mechanism, which could affect not only the scale of measurement but also the ranking between observations, we should use three indicators in order to perform a robustness analysis to the estimation results. Thus, we will also apply the “Herfindahl-Hirschman index” (HHI),¹⁰ which implicitly takes the equi-proportion as a reference (Palan, 2010). This index, widely used in the field of industrial economics, is also commonly used to measure the specialization of the economy. It consists of the sum squares of sectors’ relative sizes, measured by employment or value added. Using the same

⁸ The entropy index is based namely on Shannon (1948)’ entropy function, who used it in communication theory.

⁹ By definition, the entropy index does not allow non-positive sectoral shares. See the Appendix B for further details on the methods used to calculate the indices.

¹⁰ The Herfindahl-Hirschman index was developed by Hirschman (1945) and Herfindahl (1950). See also Hirschman (1964).

notation as above, let X_{ij} = employment/value added of industry i in country j , $i = 1, \dots, n, j = 1, \dots, k$ and $\sum_i X_{ij} = X_j$ = total employment/value-added of all industries in country j , we have:

$$(3.3) \quad HHI = \sum_i \left(\frac{X_{ij}}{X_j} \right)^2$$

Contrary to the entropy index, the value of the Herfindahl-Hirschman index increases as employment/value added becomes more concentrated in a few industries and reaches its maximum value of 1 when the overall economic activity relies on just one sector. When all industries are of the same size, the index has its minimum value of $\left(\frac{1}{i}\right)$. Similarly to the entropy index, the Herfindahl-Hirschman index also takes into account the distribution of economic activity across all sectors.

3.2.3 The level of aggregation

Lastly, we need to define the level of aggregation, i.e., the number of economic activities employed in the analysis. As noted by Bahl *et al.* (1971), a too detailed disaggregation could lead to losing the focus on the overall economy, while a too great aggregation could not capture important variations that occur within broad sectors of the economy, namely manufacturing. Since we want to analyse the impact of the economic structure on economic growth across a wide range of countries from different regions and with different income levels, it is difficult to obtain comparable highly disaggregated data.

On the other hand, since changes in industry classification – across countries or over time – may affect the results, we should collect data on employment/value added distribution across industries following the same standard industrial classification. This procedure is also relevant to assure that industry categorization captures the differences between different economic activities. As a result, we will follow the International Standard Industrial Classification of All Economic Activities (ISIC),¹¹ both third (ISIC, Rev.3.1) and fourth (ISIC, Rev.4) revisions, depending on the databases used.

¹¹ See United Nations (2008) for more details.

3.3 Data

We use data on sectoral production – both value added and employment – with different levels of aggregation for a wide range of countries. Data were taken from two databases – the National Accounts Main Aggregates database from the United Nations Statistics Division and EU KLEMS – which allowed us to construct two different panel data sets (see Appendix B for sample’s sectoral and geographical coverage).

The National Accounts Estimates of Main Aggregates database from the United Nations Statistics Division collects gross value added by kind of economic activity. Data is gathered at the one-digit level (7 sectors) – divided according to the ISIC Rev.3.1 – for more than 200 countries and territories, from 1970 onwards. Despite the considerable time span and geographic coverage, this data does not provide detailed information since it only presents values for broad economic activities.

In order to evaluate the robustness of our results to the level of aggregation used, we also consider employment and value added data from the EU KLEMS database,¹² which provides information at sectoral level for all 28 European Union Member States (EU-28) and the United States (USA), from 1970 to 2015. The division of the several economic activities is consistent with ISIC Rev.4, at the 2-digit level, which gives us information on 34 industries plus 8 aggregates.

Tables 1 and 2 present descriptive statistics for the specialization/diversification indices computed both from UN Data and EU KLEMS. As can be seen from Table 1, the level of aggregation chosen is not irrelevant, producing significant differences between the two datasets, even when controlling to the same country coverage. Our results also indicate that both dimensions – value added and employment – provide similar results, although employment dataset exhibits higher levels of specialization, on average.

Table 3.1 – Summary statistics for the specialization/diversification indices

	Value Added		Employment	
	Mean	Standard Deviation	Mean	Standard Deviation
UN Data (1-digit)	100 countries			
	449 observations			

¹² EU KLEMS database is available at www.euklems.net (accessed on June 2018).

HHI	0.246	0.064		
EI	1.612	0.227		
SI	0.458	0.158		
UN Data (1-digit)	29 countries (EU-28 + USA)			
	146 observations			
HHI	0.278	0.072		
EI	1.483	0.302		
SI	0.524	0.524		
EU KLEMS (2-digit)	29 countries (EU-28 + USA) ¹³			
	127 observations		120 observations	
HHI	0.056	0.012	0.067	0.020
EI	3.111	0.138	3.012	0.144
SI	0.353	0.081	0.345	0.124

Source: Authors own calculations.

The correlation matrices for the specialization/diversification indices, presented in Table 2, reveal different patterns between both databases. While the Herfindahl-Hirschman and the entropy indices are highly correlated in the EU KLEMS database – either considering value added or employment –, its correlation when considering UN Data is substantially lower. It should be noted, however, that in all the three scenarios the correlation value has the expected negative sign since these measures move in opposite directions. Correlations with the specialization index are hard to characterize since it is a measure of relative specialization and not a measure of absolute diversification, such as the Herfindahl-Hirschman and the entropy indices.

Table 3.2 – Correlation matrices for the specialization/diversification indices

	Value-added			Employment
UN Data (1-digit)	449 observations			
	HHI	EI	SI	
HHI	1.000			
EI	-0.281	1.000		

¹³ Data on employment from Croatia was dropped from EU KLEMS panel due to insufficient time range.

SI	0.848	-0.294	1.000			
EU KLEMS (2-digit)	127 observations			120 observations		
	HHI	EI	SI	HHI	EI	SI
HHI	1.000			1.000		
EI	-0.966	1.000		-0.835	1.000	
SI	0.459	-0.472	1.000	0.651	-0.427	1.000

Source: Authors own calculations.

4. Growth Accounting Model

For the purpose of studying the relationship between the economic structure and economic growth, we developed a panel-growth-accounting model to test the hypothesis of the former affecting the latter. As pointed out by Barro (1999), the basics of growth accounting were first presented in Solow (1957) – although, according to Griliches (1995), Solow’s work was based on previous research on the calculation of the wealth of the nation. Solow describes the growth-accounting exercise as “an elementary way of segregating variations in output per head due to technical change from those due to changes in the availability of capital per head”, considering technical change “as a short-hand expression for any kind of shift in the production function” (p. 312). This technical change was the so-called “Solow residual”, which, as noted by Barro (1999), reflects technological progress and other elements.¹⁴

By using the growth-accounting framework, we want to decompose the growth rate of aggregate output in order to assess if the economic structure plays a role in the Solow residual and, therefore, impacts on economic growth. Recall that we have in mind the “growth effects”, i.e. changes that affect permanently the growth rate, and not “level effects”, i.e. changes that affect the growth rate only in the short-run.

Following the approach used by Afonso (1997), Barro and Sala-i-Martin (2004) and Torres *et al.* (2013), we aim to estimate a general “structure effect” that will be further analysed considering countries either from diverse regions and having different income levels and different dominant sectors.

Therefore, the model presents a production function with the traditional input factors with efficiency parameters to account for variations in the quality of inputs. We have no reason to consider the economic structure as a factor of production. Thus, we assume this variable not to impact on growth directly but through the quality of inputs. Since the “structure effect” can occur through labour and capital efficiency, this explanatory variable should appear on both.

The use of panel data is justified by trying to avoid common econometric problems such as the unobserved individual heterogeneity (Wooldridge, 2002). This element can be, as Torres *et al.* (2012) pointed out, a country and/or a time effect.

¹⁴ For an extended literature background see Griliches (1995).

4.1 Estimation Procedures

In this section we present the model specification, the variables included and their expected impact.

4.1.1 Model Setup

Let's consider the following aggregate production function where Y represents output, and K and L represent capital and labor inputs, respectively, in unit terms.

$$(4.1) \quad Y = F(K, L; t)$$

For technical purposes and easier calculations, we will assume that the aggregate production function follows a Cobb-Douglas form with constant returns to scale. Since we attempt to measure the indirect impact of the structure of the economy on the aggregate output through capital and labour efficiency, we will consider the following specific production function with factor efficiency:

$$(4.2) \quad Y_{it} = [L_{it}f_{it}]^\alpha [K_{it}g_{it}]^\beta$$

in which Y is the aggregate output, L is the quantity of labor, K is the capital stock, f is the labor efficiency, g is the capital efficiency, and, α and β are, respectively, constant elasticities of L and K in relation to output. The indices i and t indicate the country and the year under consideration, respectively.

The inclusion of factor efficiency parameters, f and g , seeks to capture quality advances in labor and capital, respectively. Since L and K are measured in standard units, both account for increases in the available stock of labor and capital, respectively, whereas f and g are measured in efficiency terms.

From (4.2), after taking logarithms – indicated by a circumflex accent –, we obtain the following expression for the aggregate output growth rate:

$$(4.3) \quad \hat{Y}_{it} = \alpha[\hat{L}_{it} + \hat{f}_{it}] + \beta[\hat{K}_{it} + \hat{g}_{it}]$$

This specification, however, does not isolate the role of human capital, one of the key determinants of economic growth. The theory states that the higher the human capital, the higher the quality of labour and, consequently, its productivity. In fact, human capital is frequently included in economic growth analysis. Although, despite the remarkable acceptance of human capital as an explanatory variable, there are doubts about the frequent proxies used to measure it. Some studies tried to capture human capital by considering primary and secondary enrollment rates (Barro, 1991), the working age population with secondary (Mankiw *et al.*, 1992), the expenditure on education and health (Hartwig, 2012) or the average years of schooling of adults (Teixeira *et al.*, 2016). All of these proxies, however, fail to account for differences in the quality of education, and all of them implicitly assume learning to be determined exclusively by official education. In order to overcome this issue, we assume that factors are paid their marginal products. In this sense, by using labour first-order condition, we assume real wage to equal labour productivity:

$$(4.4) \quad \frac{dY_{it}}{dL_{it}} = \omega_{it}$$

where ω_{it} is the real wage per worker. Taking the derivatives,¹⁵ we get:

$$(4.5) \quad \omega_{it} = \alpha[L_{it}]^{\alpha-1}[f_{it}]^{\alpha}[K_{it}g_{it}]^{\beta}$$

After taking logarithms, we obtain the following expression for the real wage growth rate:

$$(4.6) \quad \hat{\omega}_{it} = (\alpha - 1)\hat{L}_{it} + \alpha\hat{f}_{it} + \beta\hat{K}_{it} + \beta\hat{g}_{it}$$

Since real wage is assumed to be determined by labour productivity, this approach allows to capture improvements in human capital. Factor efficiency parameters, f and g , are unobserved. They are considered a function of several variables as presented below. Due to problems of collinearity, it is impossible to segregate the impact of each variable in f and g . In this sense, each variable is included, indifferently, in f or g according to where it is expected to produce the higher impact.

¹⁵ All derivations are presented in the Appendix C.

The option for the chosen set of explanatory variables was based on economic growth literature. According to Greenwood *et al.* (1997), investment is believed to be a robust determinant of economic growth. It is expected to have a positive sign since the theory states that investment enhances the accumulation of production factors and, therefore, promotes economic growth.

International trade is also included, in line with Frankel and Romer (1999), Greenaway *et al.* (1999), and others, who found a positive and strong relationship between trade and growth. This variable captures the effect of economic integration within the global market, which, according to the literature, fosters innovation and allows to exploit comparative advantages and economies of scale, improving production efficiency.

The model also accounts for the role of democracy and institutions in the process of economic growth. The theory (e.g., North (1991), Easterly and Levine (2003) and Acemoglu *et al.* (2005)) argues that institutional quality is important for growth, either by promoting a better allocation of resources or by stimulating investment on production factors.

We also choose to include a variable to account for research and development (R&D). According to Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1992) and related literature, R&D contributes to the stock of knowledge, the technological progress and the productivity growth. As a result, we expect this variable to have a positive and strong relationship with economic growth.

Lastly, in line with Aschauer (1989), Canning and Fay (1993) and Easterly and Rebelo (1993), we also considered infrastructures to have a positive impact on economic growth.

4.1.1.1 Specification for labour efficiency

We consider the following specification for f , the labour efficiency factor.

$$(4.7) \quad f_{it} = F \left[\left(\frac{I_{it}}{L_{it}} \right)^{a_1} \left(\frac{IT_{it}}{L_{it}} \right)^{a_2} (Str_{it})^{a_3} \right]$$

where F is a scale factor, I represents investment, IT accounts for international trade and Str measures the economic structure,¹⁶ being more diversified or more specialized. The

¹⁶ The measurement of Str variable was discussed in the previous section.

exponents a_1 , a_2 and a_3 are constant elasticities in relation to $\left(\frac{I_{it}}{L_{it}}\right)$, $\left(\frac{IT_{it}}{L_{it}}\right)$ and Str_{it} , respectively. Since f refers to the labour-unit efficiency, variables are divided by L , except Str .

After taking logarithms, we obtain the following expression for the labour efficiency growth rate:

$$(4.8) \quad \hat{f}_{it} = a_1(\hat{I}_{it} - \hat{L}_{it}) + a_2(\widehat{IT}_{it} - \hat{L}_{it}) + a_3(\widehat{Str}_{it})$$

4.1.1.2 Specification for capital efficiency

We consider the following specification for g , the capital efficiency factor.

$$(4.9) \quad g_{it} = G \left[\left(\frac{RD_{it}}{K_{it}}\right)^{b_1} \left(\frac{Inf_{it}}{K_{it}}\right)^{b_2} (IQ_{it})^{b_3} (Str_{it})^{b_4} \right]$$

where G is a scale vector, RD represents Research & Development, and Inf accounts for infrastructures. The exponents b_1 , b_2 , b_3 and b_4 are constant elasticities in relation to $\left(\frac{RD_{it}}{K_{it}}\right)$, $\left(\frac{Inf_{it}}{K_{it}}\right)$, IQ_{it} and Str_{it} , respectively. Since g refers to the capital-unit efficiency, variables are divided by K , except IQ and Str .

After taking logarithms, we obtain the following expression for the capital efficiency growth rate:

$$(4.10) \quad \hat{g}_{it} = b_1(\widehat{RD}_{it} - \hat{K}_{it}) + b_2(\widehat{Inf}_{it} - \hat{K}_{it}) + b_3(\widehat{IQ}_{it}) + b_4(\widehat{Str}_{it})$$

If we substitute \hat{f} and \hat{g} in (4.6), we get:¹⁷

$$(4.11) \quad \begin{aligned} \hat{\omega}_{it} = & \gamma_1(\hat{I}_{it} - \hat{L}_{it}) + \gamma_2(\widehat{IT}_{it} - \hat{L}_{it}) + \gamma_3(\widehat{RD}_{it} - \hat{K}_{it}) + \gamma_4(\widehat{Inf}_{it} - \\ & \hat{K}_{it}) + \gamma_5(\hat{K}_{it} - \hat{L}_{it}) + \gamma_6\widehat{Str}_{it} + \gamma_7\widehat{IQ}_{it} \end{aligned}$$

¹⁷ Since we assume constant returns to scale we have $\alpha + \beta = 1$. In this sense, we can aggregate $(\alpha - 1)\hat{L}_{it}$ and $\beta\hat{K}_{it}$ into $(1 - \alpha)[\hat{K}_{it} - \hat{L}_{it}]$, where $[\hat{K}_{it} - \hat{L}_{it}]$ stands for capital intensity growth rate.

where $\gamma_1 = \alpha a_1$, $\gamma_2 = \alpha a_2$, $\gamma_3 = \beta b_1$, $\gamma_4 = \beta b_2$, $\gamma_5 = (1 - \alpha)$, $\gamma_6 = (\alpha a_3 + \beta b_4)$ and $\gamma_7 = \beta b_3$.

This last specification will serve as the basis for the empirical approach.

4.2 Data

In this section, we provide a detailed description of the proxies and data sources used in order to estimate the specified model (expression 4.11).¹⁸ Details of data sources, the variables employed in this study and their treatment are collated in Appendix D.

The dependent variable comes from two different data sources. We first employed labour compensation per hour worked (LC) as a measure of real wage. However, since this data was collected by the Organization for Economic Cooperation and Development (OECD) it only provides information for no more than 40 countries. Then, we also get data on output per worker (Out.), at constant 2010 US\$, from the International Labour Organization (ILO). This measure can also be used as a proxy for real wage since, by using labour first-order condition on model specification, we assume the real wage to equal labour productivity. Furthermore, as the model considers the real wage growth rate, we just need to guarantee that real wage and labour productivity follows the same pattern over time, not being necessarily equal.

We get data on GDP, capital stock and labour from Penn World Table database (Feenstra *et al.*, 2015). Both real GDP and capital stock are measured at constant national prices (in mil. 2011US\$). Labour force is measured by the number of persons engaged (in millions). In order to measure investment, we use as a proxy gross capital formation in national currency at constant (2010) prices, available at the National Accounts Estimates of Main Aggregates database from the United Nations Statistics Division.

In line with empirical studies on economic growth, international trade is measured by the total amount of imports and exports. To this end, we get data both on exports and imports of goods and services as a percentage of GDP from the World Development Indicators.

There is no agreement in the literature on how to measure infrastructures. The common approach consists of exploring one particular type of infrastructure, such as energy, transports or communications, and use it as a proxy for the national overall

¹⁸ The definition, measurement and data used to capture the effect of economic structure were previously discussed on Chapter 3.

infrastructure. In this study, we choose to work with the number of fixed and mobile telephone subscriptions. This proxy was already applied in similar studies and it's available for a wide range of countries. Data was provided by the International Telecommunications Union's World Telecommunication/ICT Indicators Database.

We employed two data sources to get data on Research and Development (R&D). We first use gross domestic expenditure on research and development (Exp.), collected by the UIS Data Centre from the UNESCO Institute for Statistics (UIS). This measure, however, it's only available for no more than 60 countries in our sample. In addition, it only provides information from 1997 onwards. Then, we also considered total patent applications (Pat.) as a proxy for R&D. This measure, computed from the World Intellectual Property Organization statistics database, covers the majority of countries in our sample and enlarges their time range. Both measures will be applied separately in order to measure the robustness of this variable.

To measure Institutional Quality (IQ), we applied Political Rights (PR) and Civil Liberties (CL) indices, constructed by the Freedom House. Both indices range from 1 (the freest) to 7 and allow to classify countries as being Free, Partly Free and Not Free. Despite being available for almost all the countries in the world for the period from 1972 to 2017, this measure does not exhibit clear differences across time, which dampens within-country differences. Therefore, we opt to construct a second IQ measure by using the general government net lending/borrowing as a percentage of GDP (Budget bal.). This indicator, based on data from the World Economic Outlook Database, reduces the number of observations in the sample but improves the estimated impact of IQ on economic growth.

We computed 5-year average annual growth rates¹⁹ for all the variables – with the exception of IQ – to limit the impact of business cycle fluctuations and the short-run effects due to political and financial shocks.

Our final datasets consist of samples with a time span ranging from 1981 to 2015. Panel I, built on UN Data for the measurement of economic structure, and Panel II, based on EU KLEMS, include data for 100 and 29 countries, respectively. Since some of the data are not available for all countries or years, our both panels are unbalanced and the number

¹⁹ Due to missing values, we established a minimum threshold of three observations within each 5-year period (1981-1985; 1986-1990; 1991-1995; 1996-2000; 2001-2005; 2006-2010; 2011-2015) to compute the 5-year average. In case of missing values, we computed the annual growth rate using as the base year not $t-1$ but $t-2$.

of observations varies with the chosen set of explanatory variables (see Appendix E for summary descriptive statistics).

4.3 Panel Estimation

The use of panel data techniques allows exploiting simultaneously both the time-series and the cross-section dimensions of the data. This possibility is particularly relevant since it makes possible to handle some econometric problems, such as the unobserved individual heterogeneity. Since we use a large cross-section and a relatively short time series, we do not need to care about with time series persistence (Wooldridge, 2002).

In our model, it is not hard to believe that there is a time-constant unobserved effect that captures country-specific characteristics. This unobserved heterogeneity – sometimes referred as to individual effect – may be correlated with the regressors and, consequently, the estimated coefficients are likely to be biased.

As suggested by Mundlak (1978), the key issue to panel estimation is whether or not the unobserved effect (c_i) is correlated with the explanatory variables (x_{it}). If there is no correlation – $Cov(x_{it}, c_i) = 0, t = 1, 2, \dots, T$ – then, we can assume that it follows a random distribution and we can estimate the model using or random effects methods (RE). Otherwise, if the individual effect is correlated with the explanatory variables – $Cov(x_{it}, c_i) \neq 0, t = 1, 2, \dots, T$ – we cannot assume this effect as exogenous and we should use fixed effects methods (FE) instead.²⁰ A fixed effects analysis relies on the assumption that individual effects are correlated over time, but are unrelated with other regressors. This approach, however, does not allow the inclusion of time-constant factors in x_{it} , since in that case it will be impossible to distinguish their effects from the time-constant unobservable c_i .

In order to assess the most suited method to estimate the model under study – expression (4.11) – we need to consider both random and fixed effects. Then, we should be able to apply the Hausman test²¹ to determine if the unobserved effect is correlated or not with the explanatory variables.

²⁰ See Wooldridge (2002) for a detailed explanation on unobserved effects panel data models.

²¹ The Hausman test is based on the difference between the random and fixed effects estimates. If individual unobserved effects are presented and are correlated with the regressors, then RE is biased and FE is consistent.

Transforming our model into a panel form, we get the following specification for POLS and RE:

$$(4.12) \quad \widehat{\omega}_{it} = \beta_0 + X_{it}\beta + v_{it}, \quad t = 1, 2, \dots, T$$

where $v_{it} \equiv c_i + d_t + u_{it}$ are the composite errors, the sum of the unobserved effect – both country (c_i) and time effects (d_t) – and an idiosyncratic error (u_{it}). X_{it} is the row vector of regressors and β is the corresponding vector of estimated coefficients. β_0 is the intercept.

The specification for FE gets the form of:

$$(4.13) \quad \widehat{\omega}_{it} = X_{it}\beta + \varphi_{it} + u_{it}, \quad t = 1, 2, \dots, T$$

where $\varphi_{it} \equiv \beta_0 + c_i + d_t$. The intercept (β_0) cannot be distinguished from c_i .

Our vector of regressors, X_{it} , comes from expression (4.11):

$$X_{it} = \{[\hat{I} - \hat{L}], [\widehat{IT} - \hat{L}], [\widehat{RD} - \hat{K}], [\widehat{Inf} - \hat{K}], [\hat{K} - \hat{L}], \widehat{Str}, \widehat{IQ}\}$$

We also add time-period dummies to capture the influence of aggregate (time-series) trends.

4.4 General Results

In this section, we present the results from the estimations of equations (4.12) and (4.13). We first estimated the model considering Panel I (UN Data) which includes all the 100 countries listed in the Appendix B. Countries are then divided by geographic groups, income levels and export clubs to analyse eventual diversities.

Table 4.1 – Panel data estimation of the relationship between economic structure and wage growth (Main Results)

Regression	1	2	3a	3b	3c	4a	4b	4c	5a	5b	5c
Model	FE	FE	RE	RE	RE	RE	RE	RE	FE	FE	RE
Hausman	32.56	36.395	18.86	18.97	18.72	17.66	15.99	11.64	18.49	18.81	14.24
Sample	Full	Full	Full	Full	Full	Full	Full	Full	Full	Full	Full

Wage	Out.	Out.	LC	LC	LC	LC	LC	LC	LC	LC	LC
RD	Pat.	Pat.	Pat.	Pat.	Pat.	Exp.	Exp.	Exp.	Exp.	Exp.	Exp.
IQ	Bud.	Bud.	Bud.	Bud.	Bud.	Bud.	Bud.	Bud.	FH	FH	FH
Str	HHI	HHI	HHI	EI	SI	HHI	EI	SI	HHI	EI	SI
	VA	VA°	VA	VA	VA	VA	VA	VA	VA	VA	VA
Constant	0.003 (1.34)	0.003 (0.19)	0.037 (0.60)	0.029 (0.46)	0.098 (1.47)	0.043 (1.40)	0.044 (1.38)	0.004 (0.13)	0.004 (0.69)	0.003 (0.53)	0.006* (1.86)
$[I - \bar{I}]$	0.149*** (9.71)	0.147*** (10.02)	0.429 (1.21)	0.634* (1.80)	1.116*** (3.52)	0.918** (2.15)	1.173*** (2.79)	1.550*** (4.02)	0.177*** (8.45)	0.176*** (8.38)	0.167*** (8.74)
$[\bar{I}T - \bar{I}]$	0.078*** (3.08)	0.078*** (3.05)	-2.140*** (-5.62)	-2.011*** (-5.12)	-2.311*** (-5.93)	-2.377*** (-4.82)	-2.278*** (-4.47)	-2.570*** (-5.20)	0.079** (2.42)	0.079** (2.37)	0.118*** (3.93)
$[\bar{R}D - \bar{R}]$	0.002 (0.26)	0.001 (0.23)	-0.029 (-0.26)	-0.038 (-0.33)	0.083 (0.71)	-0.562* (-1.72)	-0.527 (-1.58)	-0.658** (-1.98)	0.016 (0.98)	0.018 (1.15)	0.024 (1.61)
$[\bar{I}nf - \bar{R}]$	0.039*** (2.98)	0.038*** (2.95)	0.127 (0.51)	0.088 (0.35)	0.060 (0.24)	0.080 (0.26)	0.056 (0.18)	0.035 (0.11)	0.012 (0.70)	0.011 (0.67)	0.018 (1.25)
$[\bar{R} - \bar{I}]$	0.240*** (4.81)	0.241*** (4.83)	4.167*** (6.22)	4.062*** (5.94)	4.155*** (6.07)	4.236*** (5.13)	4.158*** (4.93)	4.008*** (4.80)	0.167*** (2.68)	0.177*** (2.85)	0.190*** (3.59)
$\bar{S}tr$	0.030 (0.41)	0.000 (0.00)	-6.142*** (-4.61)	12.227*** (3.73)	-2.463*** (-3.75)	-6.347*** (-4.10)	13.050*** (3.37)	-3.214*** (-3.80)	0.213** (2.60)	-0.464** (-2.41)	0.150*** (3.48)
IQ	-0.038 (-1.07)	-0.039 (-1.07)	-0.145 (-0.48)	-0.197 (-0.64)	-0.064 (-0.21)	-0.129 (-0.33)	-0.221 (-0.56)	-0.037 (-0.10)	0.001 (0.17)	0.002 (0.27)	-0.003 (-0.90)
Observations	385	385	167	167	167	127	127	127	220	220	220
R^2	0.471	0.471	0.304	0.281	0.269	0.359	0.338	0.349	0.518	0.515	0.525
	Similar results with EI_VA and SI_VA.										

Notes: The dependent variable is the wage growth rate, measured either by output per worker (Out.) or labour compensation (LC). Time dummy variables are not presented due to space limitations. The *t*-statistics are in parentheses. Level of significance: *** 1%; ** 5%; * 10%. Estimations obtained with Stata software.

° On regression 2, economic structure (Str) is measured in absolute values, not in growth rates.

Source: Authors own calculations.

Table 4.1 presents the main results for the panel data estimation of the relationship between economic structure and economic growth. We perform the Hausman test²² for each regression in order to assess the most adequate estimation procedure – Random effects (RE) or Fixed Effects (FE). The majority of the regressions was estimated considering the random effects model, which assumes no correlation between country-specific effects with the other regressors.

In regressions 1 and 2, we use output per worker (Out.), total patent applications (Pat.), and general government net lending/borrowing in percentage of GDP (Bud.) as measures of wage (W), research and development (RD), and institutional quality (IQ), respectively. Economic structure (Str) is measured by applying the Herfindahl-Hirschman index (HHI) to 1-digit sectoral value-added (VA) data. However, while in regression 1 economic structure is measured by growth rates, in regression 2 it was measured in absolute values. The results show no difference when we run the model with economic

²² We considered a significance level of 5%.

structure measured in absolute values. Investment ($\hat{I} - \hat{L}$), international trade ($\hat{IT} - \hat{L}$), infrastructures ($\hat{Inf} - \hat{K}$) and capital intensity ($\hat{K} - \hat{L}$), all show the expected positive growth effects (at 1%). Unexpectedly, the economic structure shows no significant impact on wage growth.

In order to assess the robustness of these findings, we perform three additional regressions with different measures for Wage, RD and IQ. All the three additional regressions – 3, 4 and 5 – considered wage as measured by labour compensation per hour worked (LC). Regressions 4 and 5 measured RD by gross domestic expenditure on research and development in percentage of GDP (Exp.), and regression 5 followed the methodology employed by the Freedom House (FH) and captured institutional quality by inserting a dummy variable, which gets 1 if country i on period t was classified as ‘Free’, or 0 if it was classified as ‘Partly Free’ or ‘Not Free’.

We perform three estimations within each regression – one for each measure of economic structure: HHI_VA (the Herfindahl-Hirschman index with value added data), EI_VA (the entropy index with value added data) and SI_VA (the specialization index with value added data). Our results on both regressions 3 and 4 show not only that economic structure has a highly significant (at 1%) impact on wage growth, but also that the different economic structure measures are remarkably consistent. When the economic structure is measured by “specialization indicators” – such as HHI and SI – presents a negative effect on wage growth. On contrary, when measured by the entropy index (EI_VA) – a “diversification indicator” – this effect changes to positive. This result states that a more diversified (or less specialised) economy has a positive impact on wage growth.

The modifications of regressions 3 and 4 caused pronounced changes to the estimations results. Surprisingly, international trade ($\hat{IT} - \hat{L}$), although still highly significant, changed from a positive to a negative impact on wage growth. Infrastructures ($\hat{Inf} - \hat{K}$) no longer have a significant effect on wage growth, and research and development ($\hat{RD} - \hat{K}$) and institutional quality (IQ) remain non-significant – except on 4a (at 10%) and 4c (at 5%) for RD. Capital intensity ($\hat{K} - \hat{L}$) and investment ($\hat{I} - \hat{L}$) – except on 3a – maintain the positive significant effect. Overall, regressions 3 and 4 are quite similar, which indicates that Pat. and Exp. – both measures of RD – can be interchanged without significant differences.

The introduction of FH on regression 6 causes the economic structure to change their estimated impact on wage growth. Unlike the previous regressions, economic structure measured either by HHI or SI has a positive sign (a negative sign when measured by EI), which indicates that a more specialized (less diversified) economy is associated with wage growth. In this case, international trade $(\widehat{IT} - \widehat{L})$ has a positive and significant effect (at 1%). All the other variables remain unchanged.

Considering R^2 as a measure of the fit, regression 5 – either 5a, 5b or 5c – is the one where explanatory variables explain a higher share of the dependent variable, roughly 52%.

Our results do not allow us to conclude on the impact of economic structure on wage growth. However, since LC was not available for the majority of countries – especially for developing countries – the use of this variable as a measure of growth could have conditioned the results. The following section performs the same examination but with countries divided by clusters. This should allow us to better understand the impact of economic structure on wage growth.

4.5 Extensions

To examine the contribution of the economic structure to wage growth in more detail, we apply the same model to several subsamples of the data, either considering different geographic groups, income levels and export clubs.

4.5.1 Geographic Groups

Countries are divided by region according to World Bank country classifications (see Table B1(1) on Appendix B).

Table 4.2 – Panel data estimation of the relationship between economic structure and wage growth (by Geographic Groups)

Regression	1	3a	1	3a	1	1	1	1
Model	RE	RE	FE	RE	FE	RE	RE	RE
Hausman	8.91	4.85	51.20	19.10	26.55	8.75	2.02	3.76
Sample	EAP	EAP	ECA+NAM	ECA+NAM	LAC	MEA	SAS	SSA
Wage	Out.	LC	Out.	LC	Out.	Out.	Out.	Out.
RD	Pat.	Pat.	Pat.	Pat.	Pat.	Pat.	Pat.	Pat.
IQ	Bud.	Bud.	Bud.	Bud.	Bud.	Bud.	Bud.	Bud.
Str	HHI	HHI	HHI	HHI	HHI	HHI	HHI	HHI

	VA	VA	VA	VA	VA	VA	VA	VA
Constant	0.010** (2.31)	0.015 (1.21)	0.001 (0.39)	0.025 (0.38)	0.007 (1.16)	0.008 (0.99)	0.001 (0.12)	0.015 (0.71)
$[\hat{I} - \hat{L}]$	0.054* (1.71)	0.395 (1.61)	0.192*** (8.16)	0.501 (1.20)	0.134*** (3.74)	0.231*** (5.14)	0.009 (0.04)	0.032 (0.34)
$[\hat{IT} - \hat{L}]$	0.154*** (2.83)	-0.146 (-0.89)	0.080** (2.53)	-2.429*** (-5.45)	0.076 (1.06)	0.165* (1.76)	0.052 (0.72)	0.371*** (2.82)
$[\hat{RD} - \hat{R}]$	-0.039** (-2.00)	0.537* (1.82)	0.001 (0.08)	-0.041 (-0.32)	0.029 (1.40)	0.030** (2.02)	-0.003 (-0.03)	0.030 (0.47)
$[\hat{Inf} - \hat{R}]$	0.034 (1.48)	0.217 (0.78)	0.070*** (3.84)	0.150 (0.48)	0.065 (1.34)	0.011 (0.25)	-0.016 (-0.29)	-0.044 (-0.74)
$[\hat{R} - \hat{L}]$	0.269*** (3.59)	1.070*** (2.60)	0.282*** (3.91)	4.807*** (6.09)	0.377*** (2.89)	0.138 (0.89)	0.586** (2.32)	0.047 (0.19)
\widehat{Str}	-0.076 (-0.35)	0.480 (0.30)	0.282*** (3.56)	-6.200*** (-4.17)	0.066 (0.20)	0.042 (0.28)	-0.280 (-0.45)	-0.522 (-0.72)
IQ	0.076* (1.71)	0.256 (1.56)	-0.066 (-1.38)	-0.077 (-0.22)	0.143 (1.09)	-0.172* (-1.73)	-0.227** (-2.03)	0.435 (1.15)
Observations	58	17	190	138	60	40	20	17
R^2	0.465	0.723	0.654	0.331	0.641	0.763	0.796	0.715
	Similar results with EI_VA and SI_VA.				Insufficient observations on LC.			

Notes: The dependent variable is the wage growth rate, measured either by output per worker (Out.) or labour compensation (LC). Time dummy variables are not presented due to space limitations. The t -statistics are in parentheses. Level of significance: *** 1%; ** 5%; * 10%. Estimations obtained with Stata software.

Geographic Groups: EAP – *East Asia and Pacific*; ECA+NAM – *Europe and Central Asia + North America*; LAC – *Latin America and Caribbean*; MEA – *Middle East and North Africa*; SAS – *South Asia*; SSA – *Sub-Saharan Africa*. Source: Authors own calculations.

The disaggregation by geographic groups of the panel data estimation allows us to understand the different impact of economic structure on wage growth across different regions. Where possible we estimated both the regressions 1 and 3 in order to measure wage either by output per worker (Out.) and by labour compensation (LC).

Table 4.2 shows that, with the exception of aggregate *Europe and Central Asia* (ECA) and *North America* (NAM), economic structure has no significant impact on wage growth in none of the regions considered. Additionally, within the ECA+NAM group, we have opposite effects when measure wage using output (Out.) or labour compensation (LC). In the case of regression 1 – whose measure for wage is output – it is estimated a positive and significant impact of the economic structure. In this case, specialization promotes wage growth. Regression 3, which considers labour compensation as a wage measure, supports the opposite idea, that diversification is a major engine for wage growth. These results provide further evidence that output and labour compensation do not capture the same effects.

Overall, investment ($\hat{I} - \hat{L}$) and capital intensity ($\hat{K} - \hat{L}$) proved to be significantly and positively related with wage growth.

4.5.2 Income Levels

Countries are divided by income levels according to World Bank country classifications (see Table B1(1) on Appendix B).

Table 4.3 – Panel data estimation of the relationship between economic structure and wage growth (by Income Levels)

Regression	1	1	3a	1	3a
Model	FE	RE	RE	FE	FE
Hausman	21.53	11.43	4.30	102.82	-12.90
Sample	Low-income economies (L) and Lower-middle-income economies (LM)	Upper-middle- income economies (UM)	Upper-middle- income economies (UM)	High-income economies (H)	High-income economies (H)
Wage	Out.	Out.	LC	Out.	LC
RD	Pat.	Pat.	Pat.	Pat.	Pat.
IQ	Bud.	Bud.	Bud.	Bud.	Bud.
Str	HHI	HHI	HHI	HHI	HHI
	VA	VA	VA	VA	VA
Constant	0.026*** (3.70)	-0.002 (-0.39)	0.203 (1.27)	0.002 (0.99)	0.079*** (6.95)
$[\hat{I} - \hat{L}]$	0.136*** (3.75)	0.173*** (6.74)	1.477 (0.64)	0.103*** (5.61)	0.321*** (4.50)
$[\hat{IT} - \hat{L}]$	0.063 (1.09)	0.056 (1.17)	-5.943** (-2.39)	0.075*** (2.64)	-0.137* (-1.85)
$[\hat{RD} - \hat{R}]$	-0.004 (-0.20)	0.005 (0.47)	-0.569 (-1.21)	0.003 (0.59)	0.034* (1.69)
$[\hat{Inf} - \hat{R}]$	-0.009 (-0.32)	0.038 (1.29)	-0.187 (-0.12)	0.098*** (3.81)	0.114** (1.99)
$[\hat{K} - \hat{L}]$	-0.071 (-0.59)	0.463*** (6.44)	3.905 (0.84)	0.302*** (4.74)	0.803*** (4.59)
\widehat{Str}	-0.476** (-2.40)	0.281*** (2.88)	-4.404 (-0.71)	-0.032 (-0.29)	-0.170 (-0.59)
IQ	0.104 (0.98)	0.052 (0.90)	1.502 (0.47)	-0.076** (-2.29)	-0.020 (-0.23)
Observations	98	102	24	185	143
R^2	0.547	0.668	0.852	0.567	0.644

Notes: The dependent variable is the wage growth rate, measured either by output per worker (Out.) or labour compensation (LC). Time dummy variables are not presented due to space limitations. The t -statistics are in parentheses. Level of significance: *** 1%; ** 5%; * 10%. Estimations obtained with Stata software.

Income Levels (IL): L – *Low-income economies*; LM – *Lower-middle-income economies*; UM – *Upper-middle-income economies*; H – *High-income economies*.

Source: Authors own calculations.

As stated in column 1, we can expect a negative and significant (at 5%) effect of economic structure, which indicates that economic structure has a significant impact on wage growth for poor countries. For richer countries, the economic structure appears to be non-significant, with the exception of a positive impact for upper-middle-income economies when the wage is measured by output per worker.

Table 4.3 also shows that investment ($\hat{I} - \hat{L}$) and capital intensity ($\hat{K} - \hat{L}$) are powerful explanatory variables (at 1%), even when wage is the measured either by output or labour compensation, as in the case of high-income economies. Following the unexpected results of the previous sections, international trade ($\hat{IT} - \hat{L}$) presents a highly significant negative coefficient on regression 3 (wage is measured by labour compensation). Interestingly, both research and development ($\hat{RD} - \hat{K}$) and infrastructures ($\hat{Inf} - \hat{K}$) present a positive and significant impact on wage growth only for high-income economies.

4.5.3 Export Clubs

The inclusion of some countries in export clubs (EC) is based on the classification of the United Nations Conference on Trade and Development (UNCTAD).

Table 4.4 – Panel data estimation of the relationship between economic structure and wage growth (by Export Clubs)

Regression	1	1	1	1	1	1
Model	FE	RE	RE	FE	RE	FE
Hausman	-79.39	2.63	12.12	24.38	2.17	33.79
Sample	Exporters of petroleum (a)	Exporters of manufactured goods (b)	Exporters of manufactured goods and primary commodities (c)	Exporters of agricultural products (d)	Exporters of minerals and mining products (e)	All other countries
Wage	Out.	Out.	Out.	Out.	Out.	Out.
RD	Pat.	Pat.	Pat.	Pat.	Pat.	Pat.
IQ	Bud.	Bud.	Bud.	Bud.	Bud.	Bud.
Str	HHI	HHI	HHI	HHI	HHI	HHI
	VA	VA	VA	VA	VA	VA
Constant	-0.002 (-0.25)	0.008** (2.03)	0.007 (1.43)	0.023 (1.74)	0.031** (2.23)	0.003 (1.18)
$[\hat{I} - \hat{L}]$	0.145** (2.37)	0.133*** (4.34)	0.300*** (7.26)	0.105 (1.41)	0.091 (0.62)	0.133*** (6.94)
$[\hat{IT} - \hat{L}]$	0.022 (0.18)	0.133** (2.26)	0.176*** (3.19)	0.052 (0.41)	-0.044 (-0.23)	0.091*** (3.50)
$[\hat{RD} - \hat{K}]$	-0.028 (-0.73)	0.008 (0.58)	0.009 (0.71)	-0.007 (-0.12)	0.063 (1.24)	0.006 (0.97)

$[\widehat{Inf} - \widehat{K}]$	0.036 (0.56)	0.001 (0.06)	0.001 (0.03)	0.053 (0.86)	0.003 (0.03)	0.022 (1.44)
$[\widehat{K} - \widehat{L}]$	0.593** (2.31)	0.214*** (2.66)	0.119 (1.54)	0.539 (1.22)	-0.317 (-0.90)	0.214*** (3.87)
\widehat{Str}	0.441*** (3.12)	0.019 (0.08)	0.365 (1.32)	0.175 (0.21)	-1.512*** (-3.30)	-0.215** (-2.34)
IQ	0.045 (0.48)	-0.049 (-0.98)	-0.027 (-0.36)	0.694 (1.67)	0.484** (2.40)	-0.055 (-1.23)
Observations	38	66	58	27	21	229
R^2	0.780	0.506	0.726	0.846	0.695	0.600

Notes: The dependent variable is the wage growth rate, measured either by output per worker (Out.) or labour compensation (LC). Time dummy variables are not presented due to space limitations. The *t*-statistics are in parentheses. Level of significance: *** 1%; ** 5%; * 10%. Estimations obtained with Stata software.

Export Clubs (EC):

a – AZE, BRN, COL, DZA, IRN, KAZ, KWT, RUS, SAU, TTO, VEN;

b – BER, BGD, HKG, IND, KOR, MAR, MEX, MYS, PAK, PHL, SGP, THA, TUR, UKR, VNM;

c – ARG, BGD, BRA, CHL, KOR, MAR, MEX, PAK, PHL, THA, TUR, UKR, VNM;

d – ARG, BLZ, ECU, GTM, KEN, MDA, MWI, PRY, URY;

e – ARM, CHL, JAM, KGZ, MNG, PER, TJK, ZMB.

Source: Authors own calculations.

Up to now, we have conceived the economic structure on aggregate terms, never considering individual particular sectors. In this section, we classified countries according to the dominant export activities within their national economy.

The results show economic structure to have a significant (at 1%) impact either for exporters of petroleum and in the case of exporters of minerals and mining products. However, while for exporters of minerals and mining products the effect is negative – a more diversified economy is associated with a higher grow – which can be thought in the line of ‘resource curse’ literature –, for the exporters of petroleum it is exactly the opposite with specialization positively affecting wage growth.

We also considered an extra group that encompasses all the other countries of our sample. This approach allows us to estimate the effect of economic structure excluding those countries that are highly dependent on the exports of a specific industry. Our results suggest that economic structure impacts negatively on wage growth. This is to say that a more diversified economy, as opposed to a specialized one, is believed to have a positive effect on wage growth. This result is significant at a 5% level.

All the other variables, when significant, present the expected sign, namely investment $(\widehat{I} - \widehat{L})$, international trade $(\widehat{IT} - \widehat{L})$ and capital intensity $(\widehat{K} - \widehat{L})$.

4.6 Robustness Analysis

Lastly, we assess the robustness of our results to the sector's size dimension, the indicator of specialization/diversification and the level of aggregation considered on the measurement of economic structure. This last section considers Panel II (EU KLEMS) which includes all the 28 EU Member States and the United States.

Table 4.5 – Panel data estimation of the relationship between economic structure and wage growth (Robustness Analysis for EU+US)

Regression	1	3a	4a	1	3a	3b	3c	3d	3e	3f
Model	RE	RE	RE	RE	RE	FE	FE	FE	RE	RE
Hausman	14.05	16.00	13.89	12.59	20.48	37.91	43.89	139.06	4.77	16.03
Sample	UN	UN	UN	EU	EU	EU	EU	EU	EU	EU
Wage	Out.	LC	LC	Out.	LC	LC	LC	LC	LC	LC
RD	Pat.	Pat.	Exp.	Pat.	Pat.	Pat.	Pat.	Pat.	Pat.	Pat.
IQ	Bud.	Bud.	Bud.	Bud.	Bud.	Bud.	Bud.	Bud.	Bud.	Bud.
Str	HHI	HHI	HHI	HHI	HHI	EI	SI	HHI	EI	SI
	VA	VA	VA	VA	VA	VA	VA	EMP	EMP	EMP
Constant	0.000 (0.00)	0.052 (0.57)	0.053 (1.26)	0.000 (-0.13)	0.047 (1.20)	0.121*** (2.66)	0.124** (2.60)	0.103** (2.18)	0.050 (1.08)	0.072 (1.52)
$[\hat{f} - \hat{L}]$	0.210*** (8.02)	0.477 (1.02)	0.847* (1.73)	0.198*** (6.74)	0.161 (0.97)	-0.123 (-0.62)	-0.203 (-0.99)	0.014 (0.07)	0.285 (1.40)	0.145 (0.71)
$[\hat{T} - \hat{L}]$	0.153*** (5.20)	-2.458*** (-4.73)	-2.469*** (-3.96)	0.143*** (3.62)	-0.433** (-2.00)	-0.431* (-1.84)	-0.439* (-1.78)	-0.275 (-1.05)	0.028 (0.11)	-0.154 (-0.60)
$[\hat{RD} - \hat{R}]$	0.014** (2.24)	-0.082 (-0.57)	-0.729** (-1.97)	0.006 (0.90)	0.032 (0.60)	0.025 (0.43)	0.018 (0.30)	0.034 (0.51)	-0.013 (-0.19)	-0.053 (-0.79)
$[\hat{Imf} - \hat{R}]$	0.051** (2.00)	-0.185 (-0.45)	-0.242 (-0.55)	0.061* (1.71)	0.368** (1.97)	0.260 (1.26)	0.279 (1.28)	0.415* (1.97)	0.509** (2.22)	0.264 (1.22)
$[\hat{R} - \hat{L}]$	0.297*** (5.45)	4.837*** (5.57)	4.512*** (4.69)	0.2957*** (4.58)	0.787** (2.23)	-0.090 (-0.17)	-0.505 (-0.94)	-0.164 (-0.29)	1.345*** (3.34)	1.055** (2.46)
\hat{Str}	-0.005 (-0.05)	-6.449*** (-3.89)	-6.630*** (-3.83)	0.161 (1.61)	-3.198*** (-6.01)	8.676*** (2.90)	-0.348 (-1.12)	1.775*** (2.97)	-5.963** (-2.38)	0.099 (0.26)
IQ	0.037 (1.03)	0.018 (0.03)	0.158 (0.25)	-0.006 (-0.15)	-0.213 (-1.06)	-0.388 (-1.28)	-0.615* (-1.99)	-0.631** (-2.05)	-0.055 (-0.24)	-0.196 (-0.79)
Observations	126	117	102	115	110	110	110	107	107	107
R^2	0.684	0.363	0.420	0.644	0.376	0.390	0.329	0.389	0.277	0.184

Notes: The dependent variable is the wage growth rate, measured either by output per worker (Out.) or labour compensation (LC). Time dummy variables are not presented due to space limitations. The *t*-statistics are in parentheses. Level of significance: *** 1%; ** 5%; * 10%. Estimations obtained with Stata software.

Sample: UN – UN Data; EU – EU KLEMS.

Source: Authors own calculations.

Initially, we estimate regressions 1, 3 and 4 for the 29 countries under analysis (the 28 European Member States and the United States) considering data from Panel I which collects gross value added by kind of economic activity at one-digit level (7 sectors). The results show that, when the wage is measured by labour compensation (LC), the economic

structure proves to be a significant explanatory variable (at 1%) of wage growth. When measured using the Herfindahl-Hirschman index, its impact is negatively associated with wage growth. In this sense, we can interpret higher diversification, or lower specialization, as a major factor of wage growth.

Then, we perform both regressions 1 and 3 using Panel II, which collects employment and value added data at the 2-digit level (34 industries plus 8 aggregates). Similarly to previous results, economic structure is highly significant only when the wage is measured by labour compensation (LC). This significance, however, is not uniform between indicators (HHI, EI and SI) and, even, between sector's size dimensions. Our results show that when we use the specialization index (SI) as an indicator of economic structure, its impact is estimated as being not significant. In contrast, both the Herfindahl-Hirschman index (HHI) and the entropy index (EI) exhibit a higher level of significance (1%) either when considering employment or value added as sector's size dimensions.

Curiously, the estimated impact of the economic structure on wage growth is the opposite according to the sector's size dimension considered – employment or value added –, either for HHI and EI. Our results indicate that when the economic structure is based on sectoral employment distribution, a more specialized economy is preferable for wage growth. On the contrary, when the economic structure is based on sectoral value added distribution, a more diversified economy is expected to positively impact on wage growth.

The different level of sectoral aggregation does not appear to cause significant changes in the estimated impact of the economic structure.

5. Economic Complexity

Lastly, we want to analyse whether the economic structure effect is influenced by the sectoral linkages within the economy using the network theory and the concept of “product space” created by Hausmann *et al.* (2007). We will use the economic complexity index, developed by Hidalgo and Hausmann (2009), to capture the mapping of the economy and the interactions that occur between sectors. This is essential to capture the integration of each sector on the overall structure of the economy. By opposition to Hidalgo *et al.* (2007) – that uses this map to observe the evolution of a country’s productive structure and the dynamics of production within it –, we are interested only on the impact of economic complexity within each economy. We want to understand if the effect of the economic structure on economic growth varies with the “production network”.

We will use data from the Observatory on Economic Complexity²³ (Simoes and Hidalgo, 2011). The index of economic complexity is built on interpreting trade data as a bipartite network. In this sense, countries are related to the products they export. This approach relies on the idea that the production network and the interactions that occur between different activities or sectors are the major sources of economic growth.

To assess if economic complexity plays a role in growth we will insert this variable as a regressor in the model presented in chapter 4. This variable will substitute economic structure not implying changes to the model.

5.1 Results

Table 5.1 presents the results of the model for all the four regressions considered.

Table 5.1 – Panel data estimation of the relationship between economic complexity and wage growth (Economic Complexity)

Regression	1	3	4	5
Model	FE	RE	RE	RE
Hausman	22.28	19.97	16.83	16.54
Sample	Full	Full	Full	Full
Wage	Out.	LC	LC	LC
RD	Pat.	Pat.	Exp.	Exp.
IQ	Bud.	Bud.	Bud.	FH
Constant	0.003	0.021	0.059	0.107

²³ The Observatory of Economic Complexity is available at atlas.media.mit.edu (accessed on August 2018).

	(0.85)	(0.29)	(1.19)	(1.36)
$[\hat{I} - \hat{L}]$	0.152*** (9.80)	1.207*** (3.46)	1.645*** (3.85)	1.580*** (3.87)
$[\widehat{IT} - \hat{L}]$	0.080*** (2.97)	-2.263*** (-5.35)	-2.568*** (-4.73)	-2.442*** (-4.55)
$[\widehat{RD} - \hat{K}]$	0.000 (0.00)	-0.038 (-0.31)	-0.473 (-1.31)	-0.514 (-1.46)
$[\widehat{Inf} - \hat{K}]$	0.043*** (3.17)	0.043 (0.16)	0.036 (0.11)	0.021 (0.06)
$[\hat{K} - \hat{L}]$	0.249*** (4.81)	4.085*** (5.27)	3.980*** (3.87)	4.028*** (3.96)
<i>EC</i>	0.002 (0.42)	-0.008 (-0.41)	-0.024 (-0.81)	-0.021 (-0.70)
<i>IQ</i>	-0.015 (-0.37)	-0.273 (-0.82)	-0.178 (-0.42)	-0.053 (-0.68)
Observations	358	163	124	126
R^2	0.486	0.224	0.283	0.276

Notes: The dependent variable is the wage growth rate, measured either by output per worker (Out.) or labour compensation (LC). Time dummy variables are not presented due to space limitations. The *t*-statistics are in parentheses. Level of significance: *** 1%; ** 5%; * 10%. Estimations obtained with Stata software.

This sample includes all the countries listed in Appendix B, with the exception of ARM, BLZ, BRB, BRN, CYP, ISL, KGZ, LUX, MWI, MLT and TJK.

Source: Authors own calculations.

Economic complexity does not appear to be a significant explanatory variable of wage growth. This result was confirmed in all four model specification that considers different proxies for wage, research and development (RD) and institutional quality (IQ). Although not significant, economic complexity should play a role in growth. However, we must be aware that we are dealing with trade data, and it does not include products that are produced and consumed in the domestic market and is limited to goods, excluding data on services (Bustos *et al.*, 2012).

All the other significant explanatory variables present the expected positive value – with the exception of international trade ($\widehat{IT} - \hat{L}$) that presents a negative sign on regressions 3, 4 and 5.

6. Conclusions

This study evaluates the relationship between economic structure and growth. It can be included on the old line of economic thought that considers economic structure as an important factor to determine the rate of growth of the economy.

We start by discussing the concept of economic structure and how to measure it. Sometimes referred to as the “production structure”, it is still a quite vague idea that is modelled in various ways, accordingly with the context, the authors’ intents and the data available. In this study, we assume an economy is diversified if there is no industry or group of industries that account for a large share of economic activity. On the contrary, a specialized economy is the one where one or a few sectors represent a large amount of national production.

For the purpose of studying the relationship between the economic structure and economic growth, we developed a panel-growth-accounting model to test the hypothesis of the former affecting the latter. By using labour first-order condition, we assess the impact of economic structure on wage growth. Our results, using value added data, indicate that a more diversified economy, as opposed to a more specialized one, positively impacts on wage growth. Interestingly, when considering employment dimension the results are the opposite and specialization is expected to be associated with wage growth, which follows Marshall (1890)’ theory of productivity gains through process innovation. To examine the contribution of the economic structure to wage growth in more detail, we applied the same model to several subsamples of the data, either considering different geographic groups, income levels and export clubs. The impact of economic structure on wage growth it’s only significant for the aggregate of Europe and Central Asia and North America, which is not consistent with our finding that economic structure has a higher impact on low income countries. Regarding export clubs, the results show economic structure to have a significant impact either for exporters of petroleum and in the case of exporters of minerals and mining products. However, while for exporters of minerals and mining products the effect is negative – a more diversified economy is associated with a higher grow – which can be thought in the line of ‘resource curse’ literature –, for the exporters of petroleum it is exactly the opposite with specialization positively affecting wage growth. Economic complexity does not appear to be a significant explanatory variable of wage growth.

Future research on the relationship between economic structure on economic growth should try to explore not only different sector's size dimensions, but also and particularly lower levels of aggregation. Another possible line of study could be developing our understanding on the linkages between sectors and their impact on growth through productivity and innovation gains.

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Appendix A: Literature on Economic Structure measurement

Authors (Year)	Dimension considered	Indicator used	Country/Area
McLaughlin (1930)	Value Added	Concentration ratio in the five (and twenty) largest industries	16 American Cities
Tress (1938)	Employment	The crude diversity index	British Isles
Florence (1948)	Employment	The national average index	United States (50 states)
Leser (1949)	Employment	Index of differences	Regions of Great Britain
Reinwald (1949)	Employment	Concentration ratio in the leading industry and the two largest industrial groups A Lorenz Index for the five leading industries	American industrial areas
Steigenga (1955)	Employment	Standard deviation	Dutch towns
Rodgers (1957)	Employment	The Crude Diversification Index	93 Industrial areas of United States
Davis and Hagger (1960)	Employment	The Herfindahl Index	South Wales
Ullman and Dacey (1960, 1969)	Employment	The Minimum Requirements approach	American cities
Conkling (1963)	Employment Production	A graphic method, a variation of the Lorenz curve	South Wales
Hackbart and Anderson (1975)	Employment	The Entropy Index	United States (State of Wyoming)
Kort (1981)	Employment	The Entropy Index The Ogive Index The national average index The per cent durable diversification index	106 American metropolitan areas
Attaran (1986)	Employment	The Entropy Index	United States (50 states and the District of Columbia)
Glaeser <i>et al.</i> (1992)	Employment	Concentration ratio in the five largest industries	170 American Cities
Izraeli and Murphy (2001)	Employment	The Herfindahl Index	United States (17 states)
Imbs and Wacziarg (2003)	Employment Value Added	The Gini coefficient The Herfindahl Index The coefficient of variation	67 Countries

		The max-min spread The log-variance The share of the biggest sector The mean-median spread The interquartile range	
Aiginger and Davies (2004)	Value Added	The Entropy Index	14 Countries of European Union
Klinger and Lederman (2004)	Exports	The Herfindahl Index	70 Countries
Van Stel and Nieuwenhuijsen (2004)	Employment	Adjusted concentration ratio in the three smallest sectors	Netherlands (NUTS 3 level)
Frenken <i>et al.</i> (2007)	Employment	The Entropy Index	Netherlands (NUTS 3 level)
Mas <i>et al.</i> (2008)	Value Added Employment	The Coefficient of Variation The Index of differences in industries' composition	Spain Italy
Hong and Xiao (2016)	Employment	The Herfindahl Index The Entropy Index The Multiple Specializations Indicator	353 American Metropolitan Statistical Areas

Appendix B: Data Coverage

B1 – Panel I (UN Data)

The National Accounts Main Aggregates database from the United Nations Statistics Division provides data on gross value added by kind of economic activity, in national currency at constant (2010) prices, for more than 200 countries or territories, from 1970 onwards. Our final dataset consists of a sample of 449 observations for 100 countries from 1981 to 2015.

Countries are divided by region and income levels (IL) according to World Bank country classifications. The inclusion of some countries in export clubs (EC) is based on the classification of the United Nations Conference on Trade and Development (UNCTAD).

Table B1(1) – Country Coverage²⁴

East Asia and Pacific (EAP)

Code	Country	Period	IL	EC	Code	Country	Period	IL	EC
AUS	Australia	1996-2015	H	-	MNG	Mongolia	1991-2015	LM	e
BRN	Brunei Darussalam	1996-2010	H	a	MYS	Malaysia	1991-2015	UM	b
HKG	Hong Kong	1991-2015	H	b	NZL	New Zealand	1991-2015	H	-
IDN	Indonesia	1991-2015	LM	-	PHL	Philippines	1991-2015	LM	b,c
JPN	Japan	1991-2015	H	-	SGP	Singapore	1996-2015	H	b
KHM	Cambodia	2006-2015	LM	-	THA	Thailand	1991-2015	UM	b,c
KOR	Republic of Korea	1991-2015	H	b,c	VNM	Vietnam	1991-2015	LM	b,c

Europe and Central Asia (ECA)

Code	Country	Period	IL	EC	Code	Country	Period	IL	EC
ALB	Albania	1996-2015	UM	-	ISL	Iceland	1991-2015	H	-
ARM	Armenia	1996-2015	LM	e	ITA	Italy	1981-2015	H	-
AUT	Austria	1991-2015	H	-	KAZ	Kazakhstan	1996-2015	UM	a
AZE	Azerbaijan	1996-2015	UM	a	KGZ	Kyrgyzstan	1996-2015	LM	e
BEL	Belgium	1991-2015	H	-	LTU	Lithuania	1996-2015	H	-
BGR	Bulgaria	1991-2015	UM	-	LUX	Luxembourg	1991-2015	H	-
BIH	Bosnia and Herzegovina	2001-2015	UM	-	LVA	Latvia	1996-2015	H	-
BLR	Belarus	1996-2015	UM	b	MDA	Moldova	1996-2015	LM	d
CHE	Switzerland	1991-2015	H	-	MKD	Macedonia	1996-2015	UM	-
CYP	Cyprus	2001-2015	H	-	NLD	Netherlands	1991-2015	H	-
CZE	Czech Republic	1996-2015	H	-	NOR	Norway	1981-2015	H	-
DEU	Germany	1991-2015	H	-	POL	Poland	1991-2015	H	-
DNK	Denmark	1981-2015	H	-	PRT	Portugal	1991-2015	H	-

²⁴ Country codes follows International Standards Organization (ISO) 3-digit alphabetic codes.

ESP	Spain	1991-2015	H	-	ROU	Romania	1991-2015	UM	-
EST	Estonia	1996-2015	H	-	RUS	Russian Federation	1991-2015	UM	a
FIN	Finland	1981-2015	H	-	SVK	Slovakia	1996-2015	H	-
FRA	France	1981-2015	H	-	SVN	Slovenia	1996-2015	H	-
GBR	United Kingdom	1991-2015	H	-	SWE	Sweden	1991-2015	H	-
GEO	Georgia	1991-2015	LM	-	TJK	Tajikistan	2001-2015	LM	e
GRC	Greece	1991-2015	H	-	TUR	Turkey	1991-2015	UM	b,c
HRV	Croatia	1996-2015	UM	-	UKR	Ukraine	1991-2015	LM	b,c
HUN	Hungary	1991-2015	H	-	UZB	Uzbekistan	1996-2015	LM	-
IRL	Ireland	1991-2015	H	-					

Latin America and Caribbean (LAC)

Code	Country	Period	IL	EC	Code	Country	Period	IL	EC
ARG	Argentina	1991-2015	UM	c,d	JAM	Jamaica	2001-2015	UM	e
BLZ	Belize	2006-2015	UM	d	MEX	Mexico	1991-2015	UM	b,c
BRA	Brazil	1991-2015	UM	c	PAN	Panama	1996-2015	UM	-
BRB	Barbados	2001-2015	H	-	PER	Peru	1991-2015	UM	e
CHL	Chile	1991-2015	H	c,e	PRY	Paraguay	2001-2010	UM	d
COL	Colombia	1991-2015	UM	a	TTO	Trinidad and Tobago	1991-2015	H	a
DOM	Dominican Republic	2001-2015	UM	-	URY	Uruguay	1991-2015	H	d
ECU	Ecuador	1991-2010	UM	d	VEN	Venezuela	1991-2000	UM	a
GTM	Guatemala	1991-2015	LM	d					

Middle East and North Africa (MEA)

Code	Country	Period	IL	EC	Code	Country	Period	IL	EC
DZA	Algeria	1991-2015	UM	a	MAR	Morocco	1991-2015	LM	b,c
EGY	Egypt	1991-2015	LM	-	MLT	Malta	1991-2015	H	-
IRN	Iran, Islamic Rep. of	1991-2015	UM	a	SAU	Saudi Arabia	1991-2005	H	a
ISR	Israel	1991-2015	H	-	SYR	Syrian Arab Rep.	1991-2005	LM	-
JOR	Jordan	2001-2010	LM	-	TUN	Tunisia	1991-2015	LM	-
KWT	Kuwait	1996-2015	H	a	YEM	Yemen	2001-2015	LM	-

North America (NAM)

Code	Country	Period	IL	EC	Code	Country	Period	IL	EC
CAN	Canada	1981-2015	H	-	USA	United States	1981-2015	H	-

South Asia (SAS)

Code	Country	Period	IL	EC	Code	Country	Period	IL	EC
BGD	Bangladesh	1991-2015	LM	b,c	LKA	Sri Lanka	1991-2015	LM	-
IND	India	1991-2015	LM	b	PAK	Pakistan	1991-2015	LM	b,c

Sub-Saharan Africa (SSA)

Code	Country	Period	IL	EC	Code	Country	Period	IL	EC
KEN	Kenya	1996-2015	LM	d	MWI	Malawi	1991-2000	L	d
MDG	Madagascar	1996-2015	L	-	ZAF	South Africa	1991-2015	UM	-
MOZ	Mozambique	2001-2015	L	-	ZMB	Zambia	2001-2015	LM	e

Notes:

Income Levels (IL): L – *Low-income economies*; LM – *Lower-middle-income economies*; UM – *Upper-middle-income economies*; H – *High-income economies*.

Export Clubs (EC): a - *Exporters of petroleum*; b - *Exporters of manufactured goods*; c - *Exporters of manufactured goods and primary commodities*; d - *Exporters of agricultural products*; e - *Exporters of minerals and mining products*.

Data collected by UN Database is based on a past version of the International Standard Industrial Classification of All Economic Activities – ISIC Rev.3.1 -, and is presented on 7 broad categories: *Agriculture, Hunting, Forestry and Fishing* (A-B), *Mining, Manufacturing, Utilities* (C-E), *Manufacturing* (D), *Construction* (F), *Wholesale, Retail Trade, Restaurants and Hotels* (G-H), *Transport, Storage and Communication* (I) and *Other Activities* (J-P). In order to improve sectoral disaggregation, we subtract *Manufacturing* (D) from *Mining, Manufacturing, Utilities* (C-E), creating a new aggregate: *Mining, Utilities* (C and E)²⁵.

Table B1(2) – Sectoral Coverage

Section	Description
A-B	Agriculture, Hunting, Forestry, Fishing
C and E	Mining, Utilities
D	Manufacturing
F	Construction
G-H	Wholesale, Retail Trade, Restaurants and Hotels
I	Transport, Storage and Communication
J-P	Other Activities

B2 – Panel II (EU KLEMS)

The EU KLEMS database provides information at sectoral level for all 28 European Union Member States and the United States, from 1970 to 2015. We use gross value added at current prices (in millions of national currency) and the number of persons engaged (thousands) by industry as proxies for value-added and employment, respectively.

Our both datasets were constructed so that the set of industries considered on the economic structure measurement was constant over time for each country, even if it can vary across countries. The specialization index uses as the benchmark all the other countries in the sample for the exact set of industries as the country under study, which means that the benchmark adjusts for each country, time and set of industries.

²⁵ Since, by definition, the value-added from *Manufacturing* (D) cannot exceed the value-added from *Mining, Manufacturing, Utilities* (C-E) we drop all the observations where the estimated value for *Mining, Utilities* (C and E) is negative by using this procedure. This is the case for Armenia (1990-1991), Paraguay (1970-2001) and Moldova (1990-1992).

Table B2(1) – Country Coverage

Country	VA		EMP		Country	VA		EMP	
	Period	Notes	Period	Notes		Period	Notes	Period	Notes
Austria	1991-2015		1991-2015		Italy	1981-2015	B	1981-2015	
Belgium	1996-2015	A	1996-2015		Lithuania	1996-2015		1996-2015	
Bulgaria	2001-2015	B	2001-2015		Luxembourg	1996-2015	A	1996-2015	A
Cyprus	2001-2015		2001-2015		Latvia	2001-2015	A	2001-2015	
Czech Republic	1996-2015		1996-2015		Malta	2001-2015	A,C	2001-2015	A,C
Germany	1991-2015		1991-2015		Netherlands	1991-2015	B	1991-2015	
Denmark	1981-2015	B	1981-2015		Poland	2006-2015	C	2001-2015	
Estonia	1996-2015		1996-2015		Portugal	1996-2015		1996-2015	
Greece	1996-2015		1996-2015		Romania	1996-2015		1996-2015	
Spain	1991-2015		1991-2015		Sweden	1996-2015	A	1996-2015	A
Finland	1981-2015		1981-2015		Slovenia	1996-2015		1996-2015	
France	1996-2015	A	1991-2015	A	Slovakia	1996-2015		1996-2015	
Croatia	1996-2015	C	-		United Kingdom	1991-2015		1991-2015	
Hungary	1996-2015		1996-2015		United States	1981-2015		2001-2015	
Ireland	1996-2015	C	2001-2015						

Notes:

A – Values for some sectors are not disaggregated: C (*Manufacturing*) for Latvia (1995-1999) and Luxembourg; G (*Wholesale and retail trade; repair of motor vehicles and motorcycles*) for Belgium (2015), France (1975-1994) and Latvia (1995-1999); H (*Transportation and storage*) for Belgium (2015), France (1975-1994), Latvia (1995-1999), Luxembourg and Sweden; and J (*Information and Communication*) for Latvia (1995-1999) and Malta, in the case of Value-Added dataset; C (*Manufacturing*) for Luxembourg and Malta; G (*Wholesale and retail trade; repair of motor vehicles and motorcycles*) for France (1975-1989); H (*Transportation and storage*) for France (1975-1989), Luxembourg and Sweden; and J (*Information and Communication*) for Malta, in the case of Employment dataset. For the countries where this problem is restricted and does not affect all the observations, only those years were eliminated. For the countries where there is no disaggregated information for a given sector across all time period, that sector is considered as a whole, without disaggregation.

B – Values for some sectors are negative: C_19 (*Coke and refined petroleum products*) for Bulgaria (2014), Denmark (2011, 2013), Italy (2014, 2015) and Netherlands (2014). Since, by definition, the entropy index does not allow non-positive sectoral shares, the abovementioned observations were eliminated for the respective countries.

C – Values for some industries are estimated: C_19 (*Coke and refined petroleum products*) for Ireland; and H_53 (*Postal and courier activities*) for Croatia, Malta and Poland, in the case of the Value-Added dataset; H_53 (*Postal and courier activities*) for Malta, in the case of Employment dataset. When possible, values for a given industry are estimated as the difference between the corresponding aggregate and the sum of all the other respective industries. This was done only when there is information on all the other industries. H_53 (*Postal and courier activities*), for instance, was computed by the difference between H (*Transportation and Storage*) and H_49.52 (*Transport and storage*). See sectoral coverage below for further details.

The division of the several economic activities is consistent with ISIC Rev.4, at the 2 digit level, which gives us information on 34 industries plus 8 aggregates.

Table B2(2) – Sectoral Coverage

Section	Division	Description
A	01-03	AGRICULTURE, FORESTRY AND FISHING
B	05-09	MINING AND QUARRYING
C	10-33	TOTAL MANUFACTURING
	10-12	Food products, beverages and tobacco
	13-15	Textiles, wearing apparel, leather and related products
	16-18	Wood and paper products; printing and reproduction of recorded media
	19	Coke and refined petroleum products
	20-21	Chemicals and chemical products
	22-23	Rubber and plastics products, and other non-metallic mineral products
	24-25	Basic metals and fabricated metal products, except machinery and equipment
	26-27	Electrical and optical equipment
	28	Machinery and equipment n.e.c.
	29-30	Transport equipment
	31-33	Other manufacturing; repair and installation of machinery and equipment
D-E	35-39	ELECTRICITY, GAS AND WATER SUPPLY
F	41-43	CONSTRUCTION
G	45-47	WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES
	45	Wholesale and retail trade and repair of motor vehicles and motorcycles
	46	Wholesale trade, except of motor vehicles and motorcycles
	47	Retail trade, except of motor vehicles and motorcycles
H	49-53	TRANSPORTATION AND STORAGE
	49-52	Transport and storage
	53	Postal and courier activities
I	55-56	ACCOMMODATION AND FOOD SERVICE ACTIVITIES
J	58-63	INFORMATION AND COMMUNICATION
	58-60	Publishing, audiovisual and broadcasting activities
	61	Telecommunications
	62-63	IT and other information services
K	64-66	FINANCIAL AND INSURANCE ACTIVITIES
L	68	REAL ESTATE ACTIVITIES
M-N	69-82	PROFESSIONAL, SCIENTIFIC, TECHNICAL, ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES
O	84	PUBLIC ADMINISTRATION AND DEFENCE; COMPULSORY SOCIAL SECURITY
P	85	EDUCATION
Q	86-88	HEALTH AND SOCIAL WORK
R	90-93	ARTS, ENTERTAINMENT AND RECREATION
S	94-96	OTHER SERVICE ACTIVITIES
T	97-98	ACTIVITIES OF HOUSEHOLDS AS EMPLOYERS; UNDIFFERENTIATED GOODS AND SERVICES PRODUCING ACTIVITIES OF HOUSEHOLDS FOR OWN USE
U	99	ACTIVITIES OF EXTRATERRITORIAL ORGANIZATIONS AND BODIES

Appendix C: Calculation of labour first-order condition

By using labour first-order condition, we assume real wage to equal labour productivity:

$$(C.1) \quad \frac{dY_{it}}{dL_{it}} = \omega_{it}$$

where ω_{it} is the real wage per worker.

Taking the derivatives, we get:

$$(C.2) \quad \omega_{it} = [L_{it}f_{it}]^{\alpha'} [K_{it}g_{it}]^{\beta} + [L_{it}f_{it}]^{\alpha} [K_{it}g_{it}]^{\beta'}$$

$$(C.3) \quad \omega_{it} = \alpha [L_{it}f_{it}]^{\alpha-1} [L_{it}f_{it}]' [K_{it}g_{it}]^{\beta} + [L_{it}f_{it}]^{\alpha} \beta [K_{it}g_{it}]^{\beta-1} [K_{it}g_{it}]'$$

$$(C.4) \quad \omega_{it} = \alpha [L_{it}f_{it}]^{\alpha-1} [L_{it}'f_{it} + L_{it}f_{it}'] [K_{it}g_{it}]^{\beta}$$

$$(C.5) \quad \omega_{it} = \alpha [L_{it}]^{\alpha-1} [f_{it}]^{\alpha-1} [f_{it}] [K_{it}g_{it}]^{\beta}$$

Then, the equation can be simplified to yield:

$$(C.6) \quad \omega_{it} = \alpha [L_{it}]^{\alpha-1} [f_{it}]^{\alpha} [K_{it}g_{it}]^{\beta}$$

Appendix D: Definitions and Sources of Variables

Variable	Name	Description	Source	Comments
Y	GDP	Real GDP at constant national prices (in mil. 2011US\$)	Penn World Table (9.0)	
Str	Economic Structure	Gross Value Added by Kind of Economic Activity at constant (2010) prices - National currency	National Accounts Estimates of Main Aggregates database from the United Nations Statistics Division – UN Data	The Economic Structure was synthesized using three measures of specialization/diversification: the Herfindahl-Hirschman index, the entropy index and the index of specialization (see Chapter 3 for further details).
		Gross value added at current basic prices (in millions of national currency) by industry	EU KLEMS (September 2017 release)	
		Number of persons engaged (thousands) by industry		
ω	Wage	Output per worker (GDP constant 2010 US\$)	International Labour Organization (ILO) modelled estimates, May 2018	
		Labour compensation per hour worked	Organization for Economic Cooperation and Development (OECD)	This indicator is available in terms of annual growth rates.
L	Labour	Number of persons engaged (in millions)	Penn World Table (9.0)	
K	Capital stock	Capital stock at constant national prices (in mil. 2011US\$)	Penn World Table (9.0)	
I	Investment	GDP by Type of	National Accounts	

		Expenditure at constant (2010) prices - National currency: Gross Capital Formation	Estimates of Main Aggregates database from the United Nations Statistics Division – UN Data	
IT	International Trade	The total amount of imports and exports	World Development Indicators (World Bank)	The total amount of international trade was computed by summing the values of imports and exports of goods and services.
RD	Research and Development (R&D)	Total patent applications (direct and PCT national phase entries)	World Intellectual Property Organization (WIPO) statistics database	
		Gross domestic expenditure on research and development (GERD), as a percentage of GDP	UIS Data Centre from the UNESCO Institute for Statistics (UIS) – UN Data	
Inf	Infrastructures	Number of fixed and mobile telephone subscriptions	World Telecommunication/ICT Indicators Database, International Telecommunications Union	The number of fixed and mobile telephone subscriptions was summed up as a proxy for Infrastructures.
IQ	Institutional Quality	Index of Political Rights (PR) Index of Civil Liberties (CL) Freedom Status	The Freedom House, Freedom in the World Country Ratings	Both indices – PR and CL - range from 1 (highest) to 7. We computed the average of the 5-year averages both from PR and CL. Then, we followed the methodology employed by the Freedom House. Until 2003, countries whose combined average fell between 1.0 and 2.5 were designated Free; between 3.0 and 5.5 Partly Free; and

				between 5.5 and 7.0 Not Free. From 2003 onwards, countries whose combined average fall between 1.0 and 2.5 are Free; between 3.0 and 5.0 Partly Free; and between 5.5 and 7.0 are Not Free.
		General government net lending/borrowing as a percentage of GDP	World Economic Outlook Database from International Monetary Fund (IMF)	
EC	Economic Complexity	The Economic Complexity Index	The Observatory of Economic Complexity	

Appendix E: Summary Statistics

Variable		Panel I (UN Data)					Panel II (EU KLEMS)				
		100 countries					29 countries (EU28+USA)				
		Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max
\hat{Y}		449	3.300	2.983	-25.190	15.170	129	2.255	2.028	-4.939	9.592
\widehat{Str}	VA_HHI	449	-0.115	1.533	-14.110	7.650	127	0.393	1.202	-6.096	4.131
	VA_EI	449	0.026	0.630	-3.160	6.050	127	-0.085	0.219	-0.690	0.888
	VA_SI	449	-0.739	2.670	-14.160	12.360	127	-0.290	2.429	-8.543	5.184
	EMP_HHI	-	-	-	-	-	120	0.100	1.597	-9.909	5.498
	EMP_EI	-	-	-	-	-	120	-0.037	0.322	-0.730	2.410
	EMP_SI	-	-	-	-	-	120	-0.394	2.096	-8.714	7.037
$\hat{\omega}$	Output	435	1.885	2.901	-23.748	12.635	121	1.864	1.788	-0.811	9.320
	Lab. comp.	175	6.838	16.126	-3.246	201.031	118	5.655	7.058	-3.246	67.331
\hat{L}		449	1.345	1.916	-9.369	6.259	129	0.476	1.604	-4.584	5.474
\hat{R}		449	3.585	2.467	-1.990	17.160	129	2.640	1.412	-0.744	9.189
$\hat{R} - \hat{L}$		449	2.240	2.587	-5.910	14.490	129	2.164	1.734	-1.084	8.481
\hat{I}		449	3.823	7.486	-44.060	30.950	129	2.470	4.875	-13.110	15.900
$\hat{I} - \hat{L}$		449	2.477	6.977	-40.320	28.270	129	1.994	4.417	-12.255	14.663
\hat{T}		449	4.546	4.460	-30.570	20.400	129	4.180	3.413	-1.733	14.659
$\hat{T} - \hat{L}$		449	3.201	4.473	-21.200	19.120	129	3.705	3.437	-3.918	13.990
\widehat{RD}	Patents	437	1.601	14.848	-72.186	98.649	127	-2.582	14.197	-93.660	46.403
	Expenditure	220	4.835	6.934	-17.862	41.910	102	4.471	5.315	-17.781	28.089
$\widehat{RD} - \hat{R}$	Patents	437	-2.005	14.649	-77.189	97.580	127	-5.225	14.497	-98.034	43.991
	Expenditure	220	1.738	6.863	-28.578	35.189	102	1.825	5.023	-18.791	23.623
\widehat{Inf}		449	11.961	10.601	-3.919	51.411	129	6.577	6.531	-3.919	23.856
$\widehat{Inf} - \hat{R}$		449	8.375	10.057	-12.119	50.541	129	3.937	6.142	-5.380	21.724
IQ	PR	449	2.708	1.940	1	7	129	1.124	0.395	1	4
	CL	449	2.826	1.672	1	7	129	1.380	0.562	1	4
	Budget bal.	408	-1.887	4.509	-13.590	28.589	124	-2.897	2.887	-10.855	4.541

Notes: Variables denoted with a circumflex accent are growth rates. All the values presented are percentages - with the exception of both indices of IQ (PR and CL).

Source: Authors own calculations.